

Popular Science®

The What's New magazine

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JANUARY
1983

PS CAR TEST:
6 U.S.-made
economy champs

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AUTO ENGINE**
—almost ready, but...

Giant wind farms

**Now—
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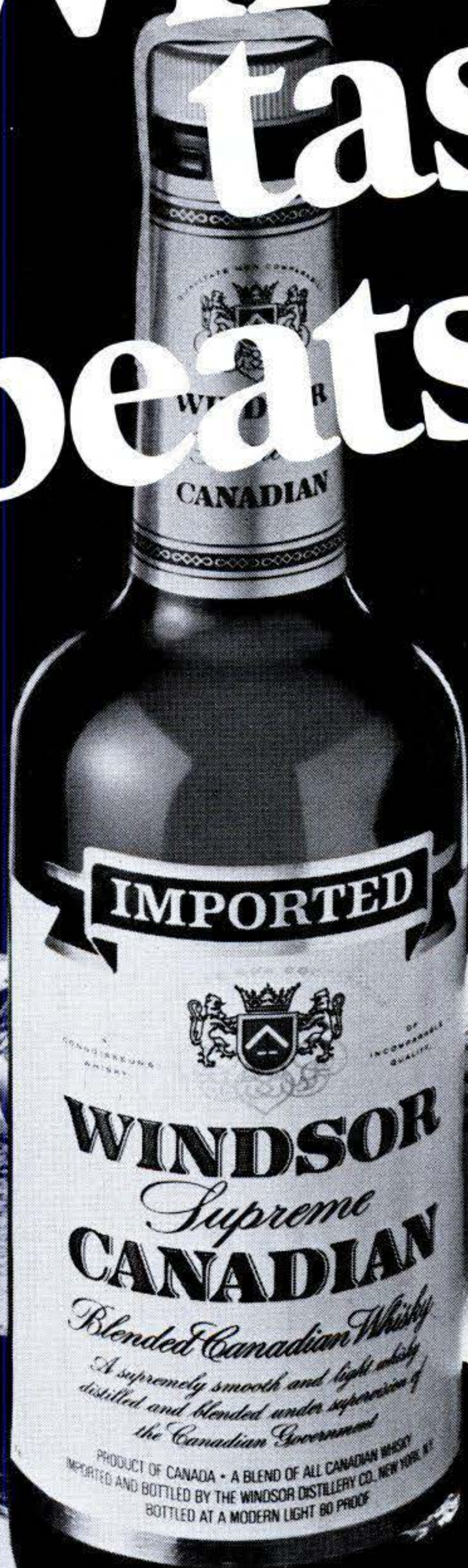
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THIS
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PS READERS TALK BACK

Address letters for this column to: Readers Talk Back, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Because of the large volume of mail, we are unable to acknowledge unpublished letters.

Missiles or margarine?

As an electrical engineer, I was fascinated to read about the technical details of advanced weapons systems ["Smart Missiles," PS, Oct. '82]. But I believe that scientists and engineers can no longer live in their "ivory laboratories," addressing technical issues without consideration of their awesome consequences. For example, it has been calculated that the outlay required for a version of the MX-missile system would be greater than the total cost to reinsulate every dwelling in the U.S. While recognizing the legitimate needs of U.S. defense, one must ask which strategy makes more sense in an energy-starved world.

The situation is worse when you consider sales of multimillion-dollar missiles to countries whose populations are burdened with great poverty, illiteracy, famine, and oppression. The costs to the world's population of the R&D, testing, manufacturing, marketing, and stockpiling of these advanced weapons should be recognized and compared with the relatively cheap costs of systems for education, food production, and health-care delivery.

I am not suggesting that POPULAR SCIENCE should become a forum for political issues. However, we must all develop a realistic perspective on the human impact and cost of new technologies, whether they be weapons systems or undersea farms.

Kevin J. Parker, Rochester, N.Y.

As usual, your magazine did a first-rate job in explaining complex technology developments to the general reader. A couple of mistakes crept in, however. In the photo captions, the names of the two British Aerospace antimissile systems are reversed. The larger picture shows the Sea Dart and the inset shows the Sea Wolf. The comments about their uses are correct, though. Second, the Copperhead anti-armor guided projectile is fired from a 155-mm artillery piece, not a tank gun as written. Current tank guns are limited to shells 120 mm or smaller.

William S. Beebee
 Guidance Systems Div., Bendix Corp.
 Teterboro, N.J.

Fallback position

Having read and had my mind flexed by POPULAR SCIENCE all my life, I am saddened that many of the exciting concepts I learned about in your pages will remain fantasies because of budget cuts in the space program ["It's Time to Stop the Space Retreat," PS, Oct. '82]. I think we

Americans owe our children the same inspiration that I found in the POPULAR SCIENCE of 25 years ago. Jim Schefter was right about another thing: The Saturn 5 rocket on display at Johnson Space Center makes a spiffy exhibit, but it's a sad sight lying there on its side—a reminder not of what was but what could have been.

Thomas E. Diegelman
 Houston, Tex.

I disagree with the editors about the space program. One of the main reasons that this nation is falling far behind in the fields of automobiles, electronics, and automation equipment is the constant drain of the best brains into better-paying jobs in the defense and aerospace industries. With huge deficits threatening our economy and 10 million unemployed, we can no longer afford the luxury of pouring billions into space programs that enrich the industrial giants but provide little benefit for the average taxpayer.

Jesse L. Taggart
 Woodstown, N.J.

I greatly appreciated your indictment of "the space retreat." As the article pointed out, our loss of leadership in this area is becoming critical and can be directly connected to faltering U.S. leadership in other areas of science and technology. However, I was disappointed that the article did not receive better billing—a mention on your cover or inclusion in the contents-page highlights.

Greg Platt, Plano, Tex.

Noisemakers

It has not yet been my displeasure to encounter one of those obnoxious talking dashboards, but when I do I'll do more than tell it to "shut up," as Jim Dunne does ["Detroit Report," PS, Oct. '82]. I'll disconnect it, just as I have done for years with those insulting key buzzers. The irony is that the purchaser pays for these uninvited intruders.

Richard J. Sawyer, Naples, Maine

Fuego figures

As a new owner and unabashed fan of the Renault Fuego Turbo, I was encouraged by the generally favorable review given it by Jim Dunne ["Sporty Quartet," PS, Sept. '82]. However, two figures cited are wrong. The EPA mileage given was for the normally aspirated Fuego, though the test car was the Turbo. The correct numbers are 24 city, 39 highway. Also, the rear seat of the Fuego does fold down, and in that

Continued

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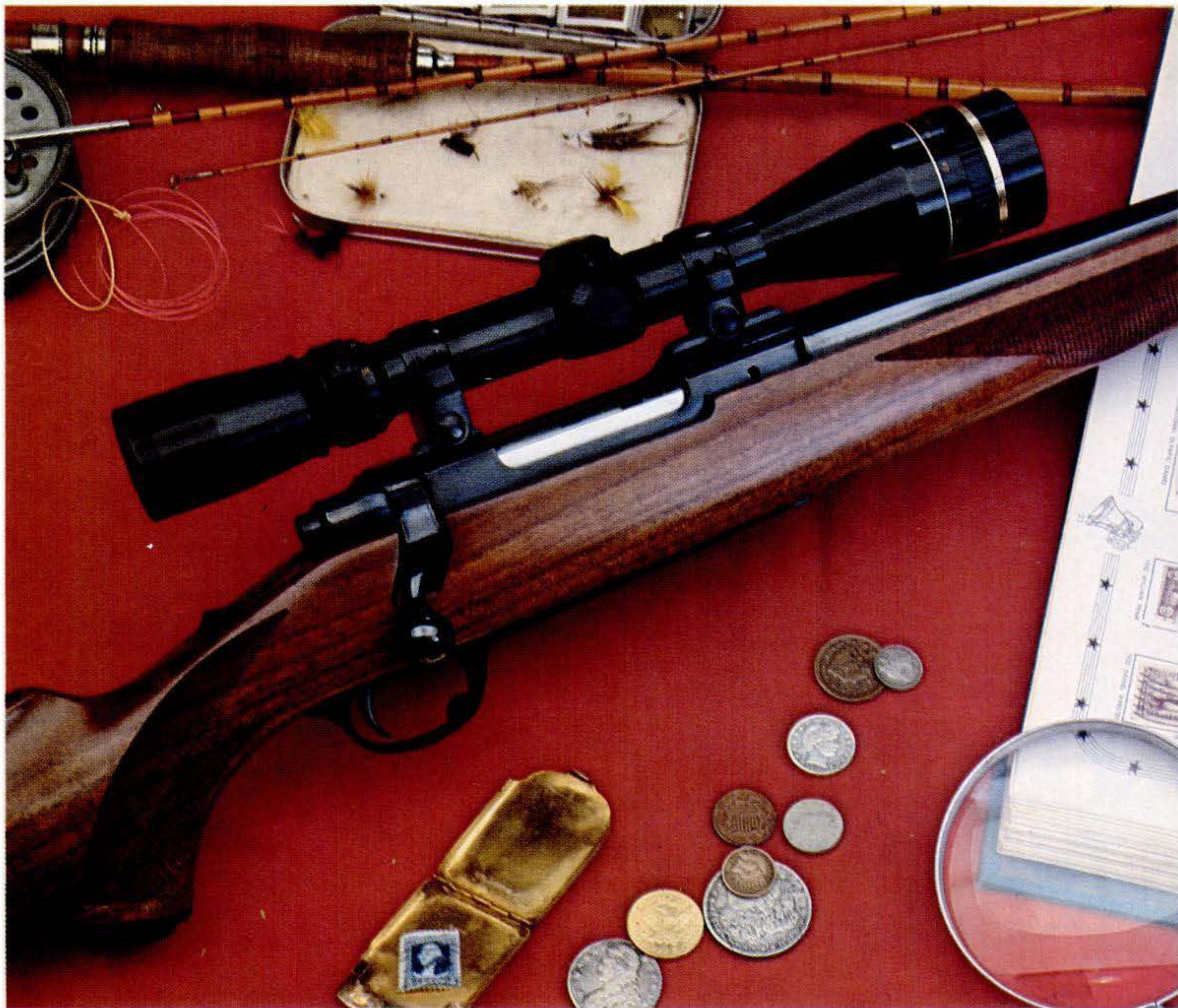
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PS readers talk back

[Continued]

configuration offers 33.8 cu. ft. of storage—superior to any of the competitors.
Thomas A. Pritchard, Hartwick, N.Y.

Cobbled up

For a \$24,000 auto, it would seem that Buick Division would make a glitch-free photo of the Riviera convertible available to POPULAR SCIENCE for editorial publicity ["GM for '83," PS, Oct. '82]. Perhaps the inattention to assembly detail, which results in the ill-fitting door (mishung by at least 1/8 in. at the hinges), accounts for 50 percent of the garages in my neighborhood housing at least one Mercedes or BMW.

Richard H. Voltz, Marietta, Ga.

Jack Keebler replies: "Many times, regular production of a model hasn't started when press long-lead information is required. Thus, manufacturers must sometimes 'cobble together' models solely for photographic purposes. The model in the photo probably doesn't incorporate the additional structural bracing that production convertibles will have. That would account for what appears to be a mishung door."

Ashes of plenty

Although the exact composition of fly ash ["Science Newsfront," PS, July '82] is dependent on the coal source and burn characteristics of the power plant, the major elements present are silicon, calcium, aluminum, iron, and magnesium. It also contains a variety of useful crystalline compounds. It is apparent that fly ash could become a new resource to be tapped rather than a waste product to be disposed of if basic research can be started now—before we are buried beneath our own ashes.

Scott Schlorholtz, Ames, Iowa

Belt in the wallet

To continue the debate over seat-belt usage [RTB, PS, May '82 and Oct. '82]: The idea of attacking the problem through insurance seems attractive, but Fritz Handel's suggestion to base premium rates on seat-belt use is probably unworkable. Insurance companies would be unable to reliably establish in advance future seat-belt usage. However, a workable method could be based on insurance coverage. Insurers could be required to pay, say, only half the usual benefits if the official finding was that the claimant was not wearing belts.

George Ray, Huntsville, Ala.

Slippery numbers

I believe you do readers a disservice by reporting drag coefficients of cars. As you know, the aerodynamic drag is given by the product of the drag coefficient, cross-sectional area, and dynamic pressure. Trying to compare aerodynamic efficiencies of various designs without knowing the area is utterly useless. Larger cars

with the same drag coefficient as smaller ones are less efficient aerodynamically in direct proportion to their relative sizes.

George L. Cahen, Alexandria, Va.

Jack Keebler replies: "Mr. Cahen is absolutely right, but, unfortunately, cross-sectional area is seldom supplied to us. Even excepting that issue, drag figures are slippery numbers. Readers should keep in mind when comparing drag coefficients in our pages or in automobile advertising that no standardized test procedure exists. The same vehicle tested in two different wind tunnels can have C_d 's varying by as much as five percent. There are also production tolerances to consider. Even in the same model, a difference of two to four percent in C_d can occur."

"Ty" for "to"

Thank you for your article about Armstrong's Tredloc ["Tougher Tire," PS, Oct. '82, page 47]. But these new radials won't cost 78 percent more, though they may be worth it. The cost is only seven to eight percent more.

Kenneth D. Backman, Manager
Product Planning, Armstrong Rubber
New Haven, Conn.

Lubing aluminum

E. F. Lindsley missed one very important property of Teflon lubes [PS, July '82]. I have found that a lube consisting of finely divided Teflon in aqueous suspension is most amazing when used on various alloys of aluminum. These seem to have a fibrous structure on which all petroleum-based lubes are practically useless. But with Teflon applied, adjustable aluminum louvers, storm doors, camera-filter threads, pipe threads, etc., remain free-working for long periods. Apparently the Teflon embeds itself in the structure of the alloys.

U. S. James Jr., Santa Fe, N.M.

Corrections: The price of the plans package for the channeled air-type solar collector from Solar Innovations (Box 6788, Great Falls, Mont. 59406) is \$12, not \$40 as printed in "Shop Talk" [PS, Oct. '82].

The correct address of the manufacturer of the PriveCode call screener ["What's New in Electronics," PS, Oct. '82] is IMM Corp., 100 N. 20th St., Philadelphia, Pa. 19103.

The Home Energy Manager control center [PS, Oct. '82] has been replaced by "a more advanced and sophisticated product called Energy Computer," according to the maker, which should have been identified as Electro Tech Manufacturing, Inc. (7094 Peachtree Industrial Blvd., Norcross, Ga. 30071).

Shortly after our November issue went to press with a "Readers Talk Back" letter about H-M Vehicles' three-wheel cars, that company announced that it was going out of business. Jim Dunne's original statement—that no three-wheelers are manufactured completely in the U.S.—is now correct.

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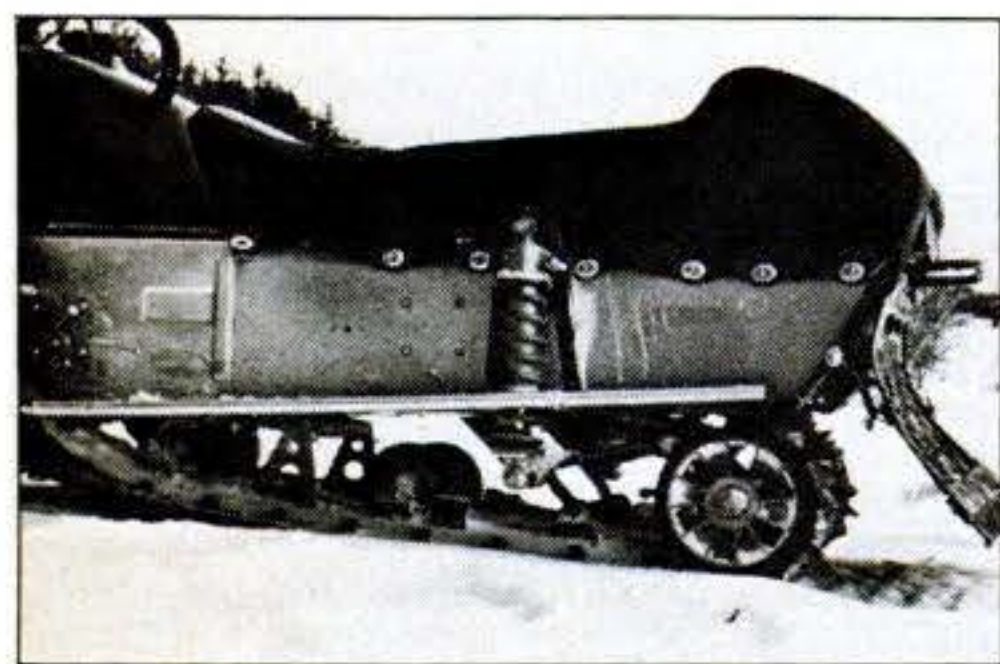
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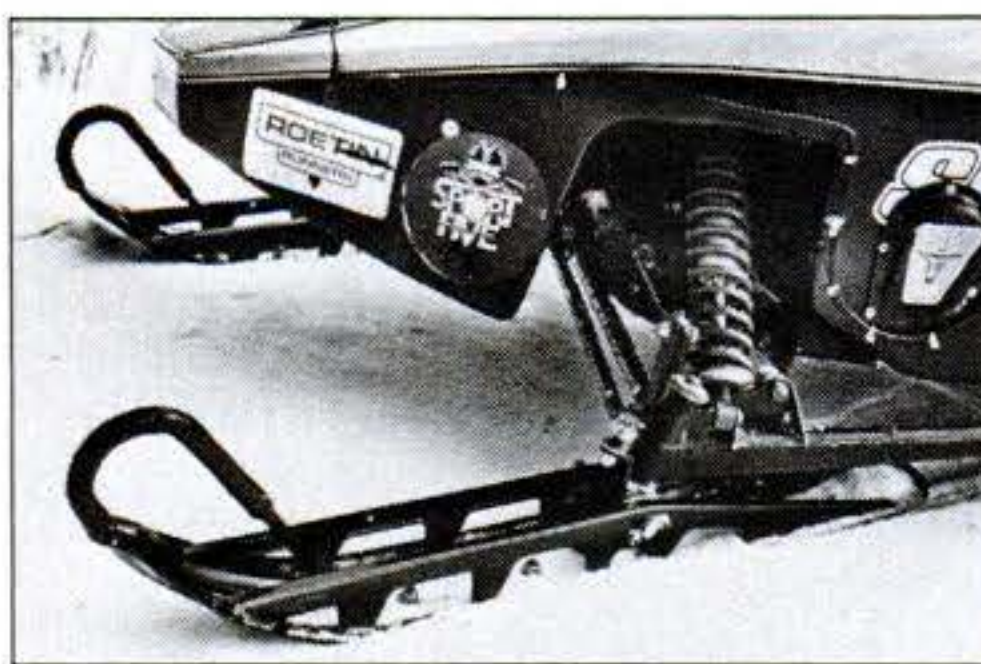
By HERBERT SHULDINER



Plush rider

Gerard Karpik tests out his frisky prototype Ski-Doo racer (above) in preparation for an assault on the race circuit this winter. Karpik, a racer and performance consultant for Bombardier, Ltd., has designed a new type of snowmobile with some of the features found in Formula 1 race cars. In the process, he claims he's laying the groundwork for a class of better-handling and more-comfortable winter machines for recreational snowmobilers.

The two major features of Karpik's snowmobile are improved aerodynamics and a sports-car-type suspension system. Karpik's racer has been tested in a wind tunnel with a rider atop the machine and came out with a coefficient-of-drag rating of 0.36. "That's quite slippery in comparison with consumer machines," Karpik says. A typical consumer snowmobile has a C_d of 0.45 with a rider aboard, Karpik adds. The most slippery automobiles have C_d 's of around 0.32. The low C_d of



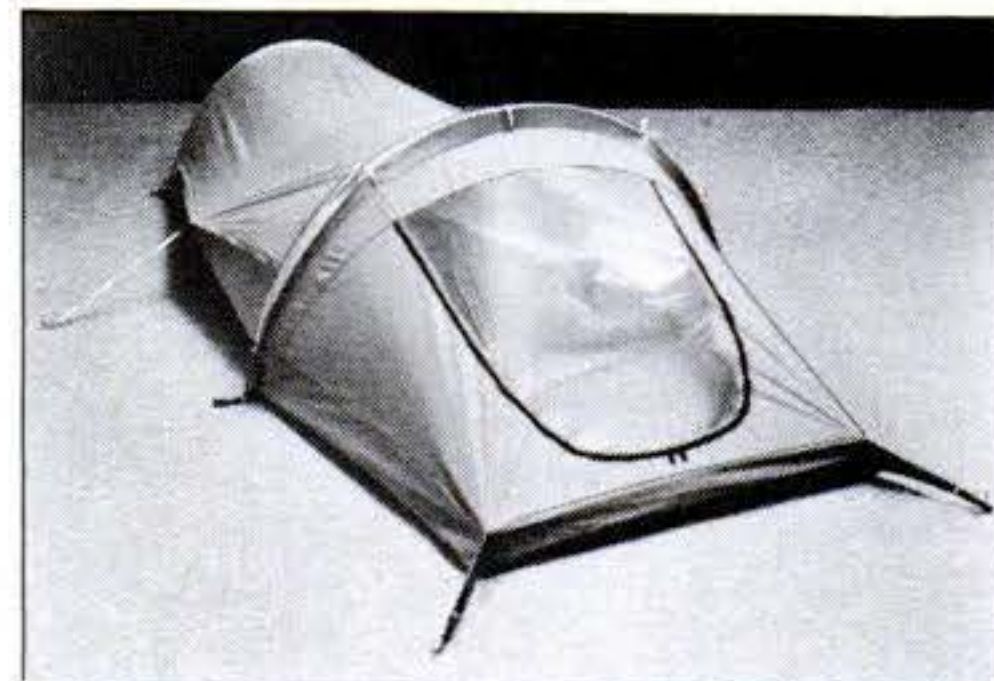
the prototype snowmobile means a higher top speed and lower fuel consumption, Karpik claims.

The efficient aerodynamics results from improved hood styling and a new windshield. One drawback to the windshield, Karpik admits, is that it offers less protection to the driver and can't be used in very cold weather. "We're aiming for a good protective windshield that still has a good drag coefficient," Karpik says.

Handling has been substantially improved with the sports-car-inspired front and rear suspension. Karpik calls it a rising-rate suspension. The way it works, Karpik says, is that when a ski moves over a small bump, the front shock moves very little in relation to ski movement. When you hit a large bump, ski and shock movement come much closer to being equal. Karpik has also designed a bell crank system to provide a variable rate of displacement for both front and rear suspension. The result is a snowmobile with good handling at high straightaway speed and the ability to take corners much faster.

Karpik's snowmobile was raced six times last winter and won four of the races. Karpik says Ski-Doo's 5500 MX already has the rear suspension developed for his prototype. In the next year or two, Karpik predicts, other Ski-Doo models will begin to get many of the features he has pioneered in his unique racing machine.

Lightweight tents



White Stag's new Stargazer tent (top photo) is a versatile shelter for use by backpackers or car campers. It features an oversize door and two windows covered with No-See-Um nylon netting, which gives ventilation and insect protection.

The tent is made of breathable nylon taffeta, and there's also a rip-stop nylon fly to protect against rain. Stargazer is rust-colored and the fly is tan. Floor size is 49 by 108 inches, and the center height is 17 inches. Weight is four pounds, six ounces. Price: less than \$85.

Sierra West's new Trilite model (bottom) provides sleeping space for three people, yet weighs only six pounds, two ounces. The tent is supported by a pair of arched, sectioned aluminum poles. The Trilite also features No-See-Um mosquito netting and has a full-coverage fly. The tent is 110 by 64 inches and is 43 inches high. There's 45.8 square feet of floor space. Price of the Trilite is \$365, including tent pegs and stuff bag.

Running partners

Do you need one? The American Running and Fitness Assn. may be able to put you in touch with other runners in your area through its Runner's Referral Service. The service is open to the entire public, and depending on where you run, distance, and pace, the service will attempt to find your match with another runner. You can get an application and more information by writing the American Running and Fitness Assn., 2420 K St. N.W., Washington, D.C. 20037. If the mail is too slow for your pace, you can call the association at (202) 965-3430.

P 5

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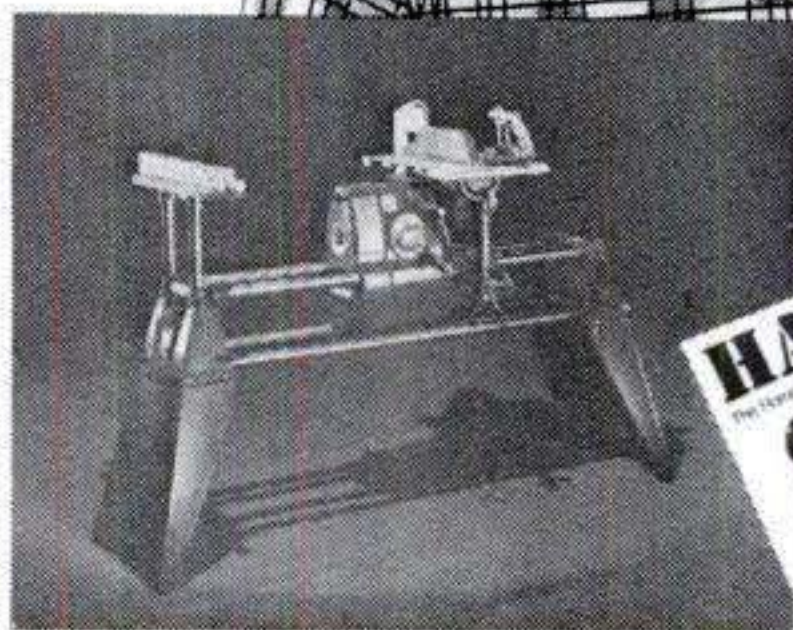
You'll be amazed at how easy you'll saw, rabbet, spindle turn, dowel and more. You'll be pleased at the professional results you'll achieve — for finished items good enough to sell!

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Whatever your level, you'll be able to do things you just can't do with individual tools. You can do it all, and chances are do it better with a MARK V!

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You can't beat the MARK V for a basic home workshop. And as your needs and skills grow, you can select from a variety of Accessory packages to add even more capabilities to your MARK V.

Darrell Vander Zanden's MARK V paid for itself! Maybe yours could, too! Find out more.

Simply complete and mail the coupon below for a FREE Information Kit, including the booklet "How To Determine Your Best Power Tool Buy." PLUS a FREE subscription to the home workshop magazine, HANDS ON! — a regular \$6.00 value. We'll even tell you how you can test-use the MARK V in your own home for 30 days, without risking a penny!

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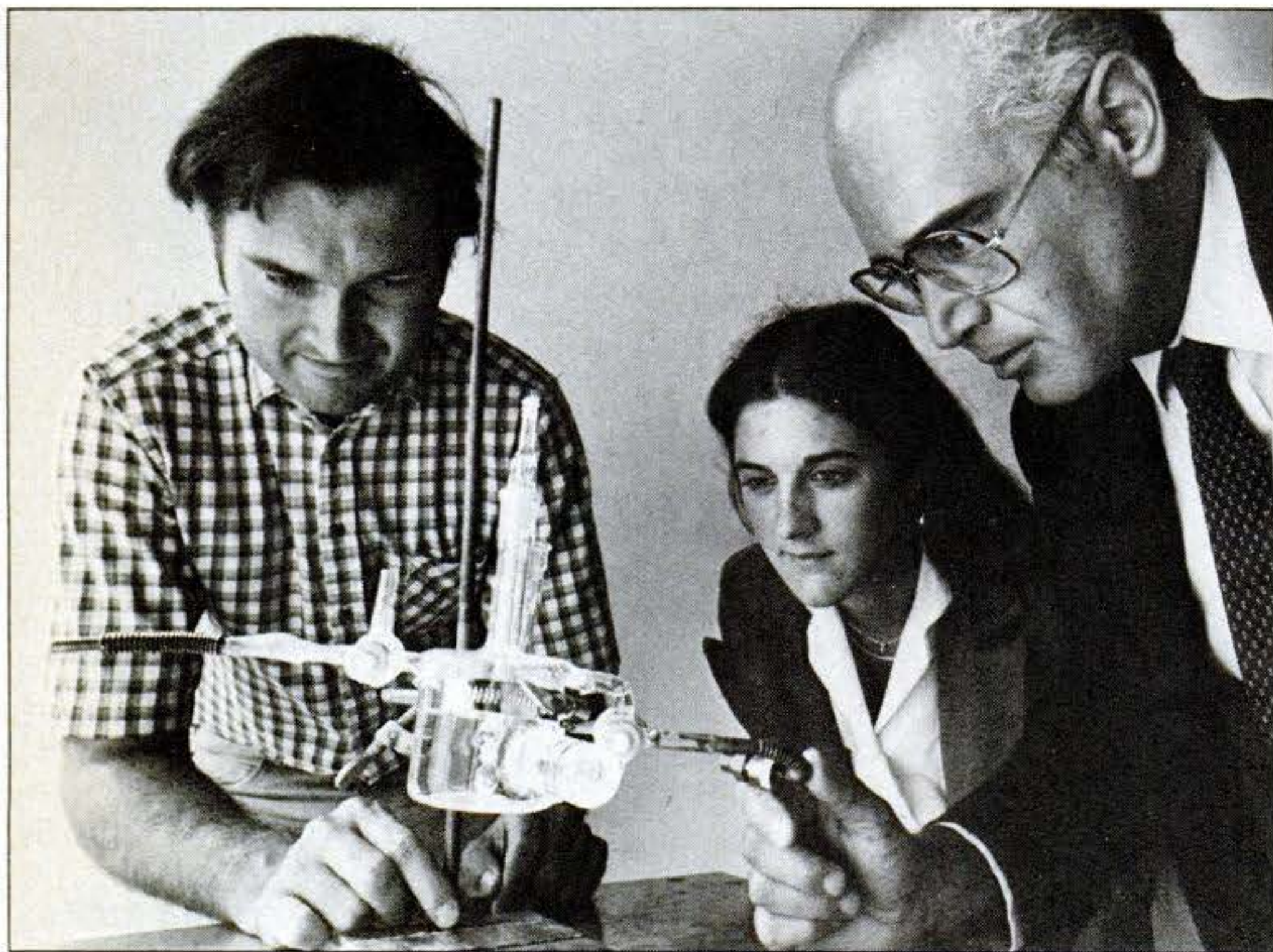
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750 Center Drive Vandalia, Ohio 45377

Dept. 360J

SCIENCE NEWSFRONT

By ARTHUR FISHER



Hydrogen fuel from water

Two sets of investigators, working independently, recently announced what they claim to be significant progress in the ongoing attempt to use sunlight to split water molecules and generate hydrogen gas.

First came a report from Professor Gabor Somorjai and his colleagues at the University of California, Berkeley. Somorjai appears at right in the photo above, with Christofer Leygraf and Monica Hendewerk. Their apparatus contains solid discs of iron oxide—compressed rust—

that act as electrodes when immersed in a solution of water and sodium sulfate. When light shines on the system, it generates an electrical current that dissociates water molecules, producing hydrogen and oxygen gases. The UC chemists say that this is the first time a photochemical process using naturally abundant raw materials has succeeded in generating hydrogen continuously at a practical level.

A few weeks after the California announcement, researchers at Texas A&M University claimed that they had achieved "a real breakthrough" in photochemical

water-splitting. Electrochemist John Bockris, of the university's Hydrogen Research Center, said his team has developed the basic technology to make from water hydrogen fuel as cheap as gasoline, perhaps for the equivalent of a dollar a gallon. The Texas system, the creation of Dr. Marek Szklarczyk and Dr. A. Q. Contractor, uses inexpensive silicon-based photoelectrodes, and achieves an efficiency of more than 10 percent—a remarkable accomplishment if the claim holds up.

Dozens of scientific groups all over the world have been pursuing the goal of a practical and economical way to use sunlight to split water molecules and yield hydrogen as an energy source [PS, Jan. '78]. But until now, no group had claimed success in combining inexpensive and recoverable materials with high efficiency. We'll report on the details of these two new systems in a later issue.

Sniffing on the assembly line

The robot seen in the photo (below, left) is actually checking cars for body leaks on the trim line for the Triumph Acclaim at a factory in Oxford, England. The check is "dry," eliminating the usual water-spray test. That wet test is unreliable in spotting sealing defects because of seepage; moreover, it can soak and damage carpets and upholstery. Dry tests simplify needed fixes and allow them to be performed early in production.

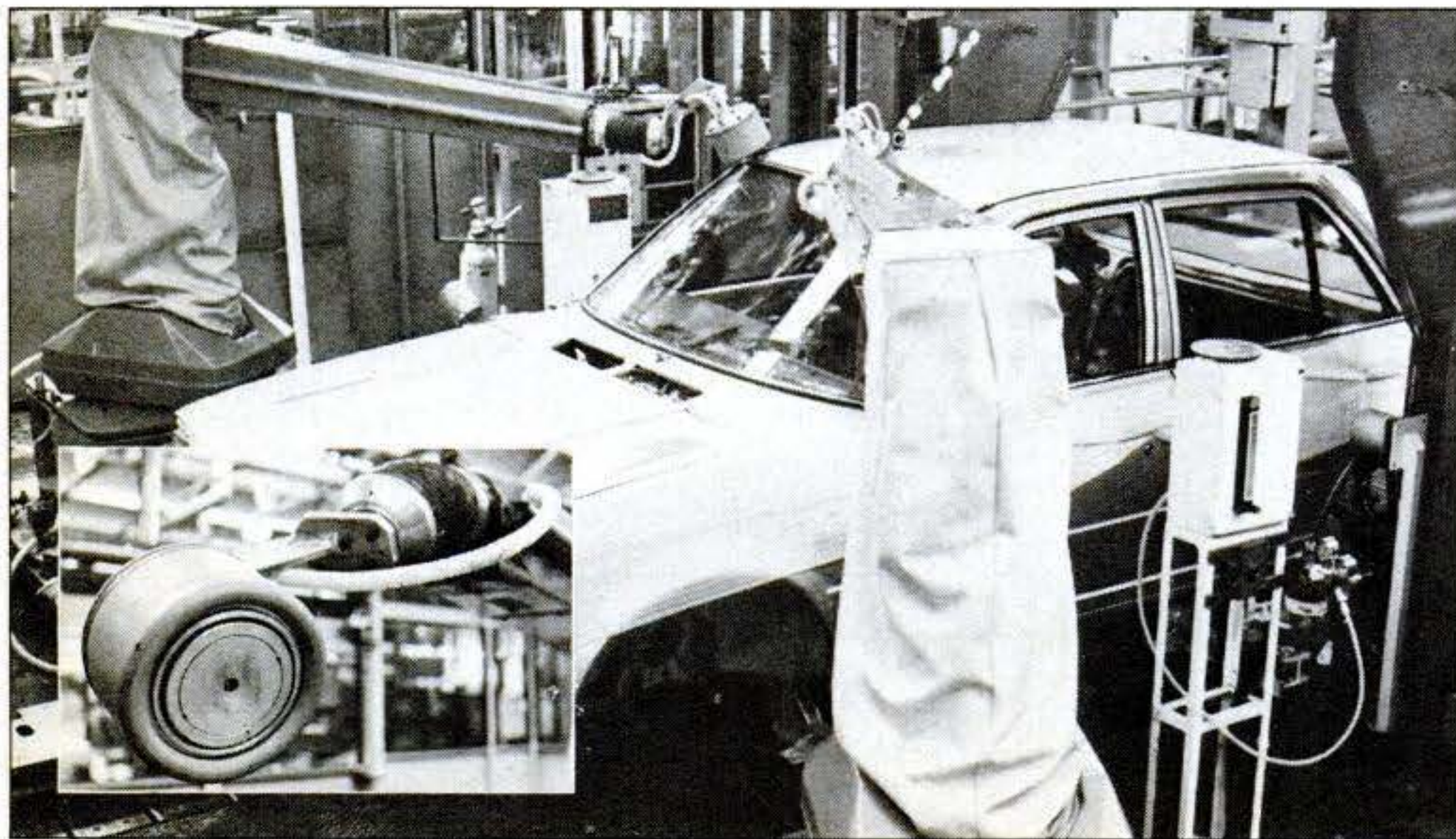
The unique system was developed by BL Cars, and it works like this: As each partly trimmed body approaches the automatic-robot station on the line, it is filled with compressed air laced with helium. The air is injected through a temporary pipe fixed to the gearshift aperture under the floor. Two robots flanking the moving track then follow the path of all body seals on both sides, including the windshield, doors, wheel arches, rear window, and trunk lid. Sensors are held within one inch of the body surface, and their central "nose" is circled by a continuous air curtain that confines any leaking gas to the sniffing area and excludes all other ambient fumes (inset photo). The exact locations and sizes of leaks are recorded on profile graphics of the car body in a computer printout. This individual record for each car is then filed as a permanent document.

Cobalt from the sea floor

Cobalt is one of those "strategic" metals. It is vitally important in many applications, including magnetic materials and superalloys. But the U.S. has none; our supply comes mostly from African mines. Now the U.S. Geological Survey announces that the bottom of the north-central Pacific Ocean may have cobalt-rich deposits that could be commercially minable in the future. The deposits occur at relatively shallow depths in waters close to the Hawaiian Islands and various U.S. Pacific territories and possessions.

The cobalt connection was uncovered by Dr. Frank T. Manheim of the USGS and Dr. Peter Halbach of the Technical Univer-

Continued



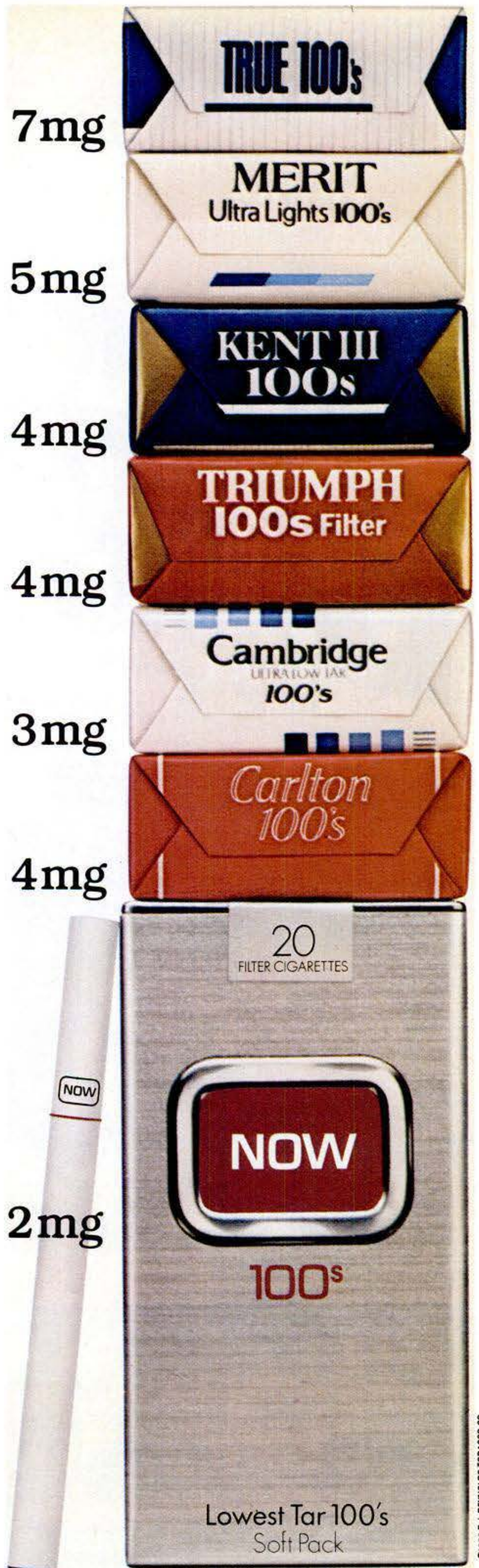
How does Now stack up?

At the bottom.

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**DATSUN LI'L HUSTLER. BORN TO BE DRIVEN
MANY MILES FOR VERY FEW DOLLARS: ONLY \$5858*.**

Datsun holds the line on the Li'l Hustler sticker price—a truck that holds the road however you drive it: as a workhorse on the job, or as the perfect second car to navigate mountain passes 11,000 feet up.

The Datsun Li'l Hustler was born for adventure. You climb into a comfortable cab behind Datsun's famous twin-ignited crossflow hemihead NAPS-Z engine, descend with standard power front disc brakes, skirt fallen rocks on adjustable torsion-bar independent front suspension. And keep driving... on quality built in by Nissan. Durable? Eight of every ten

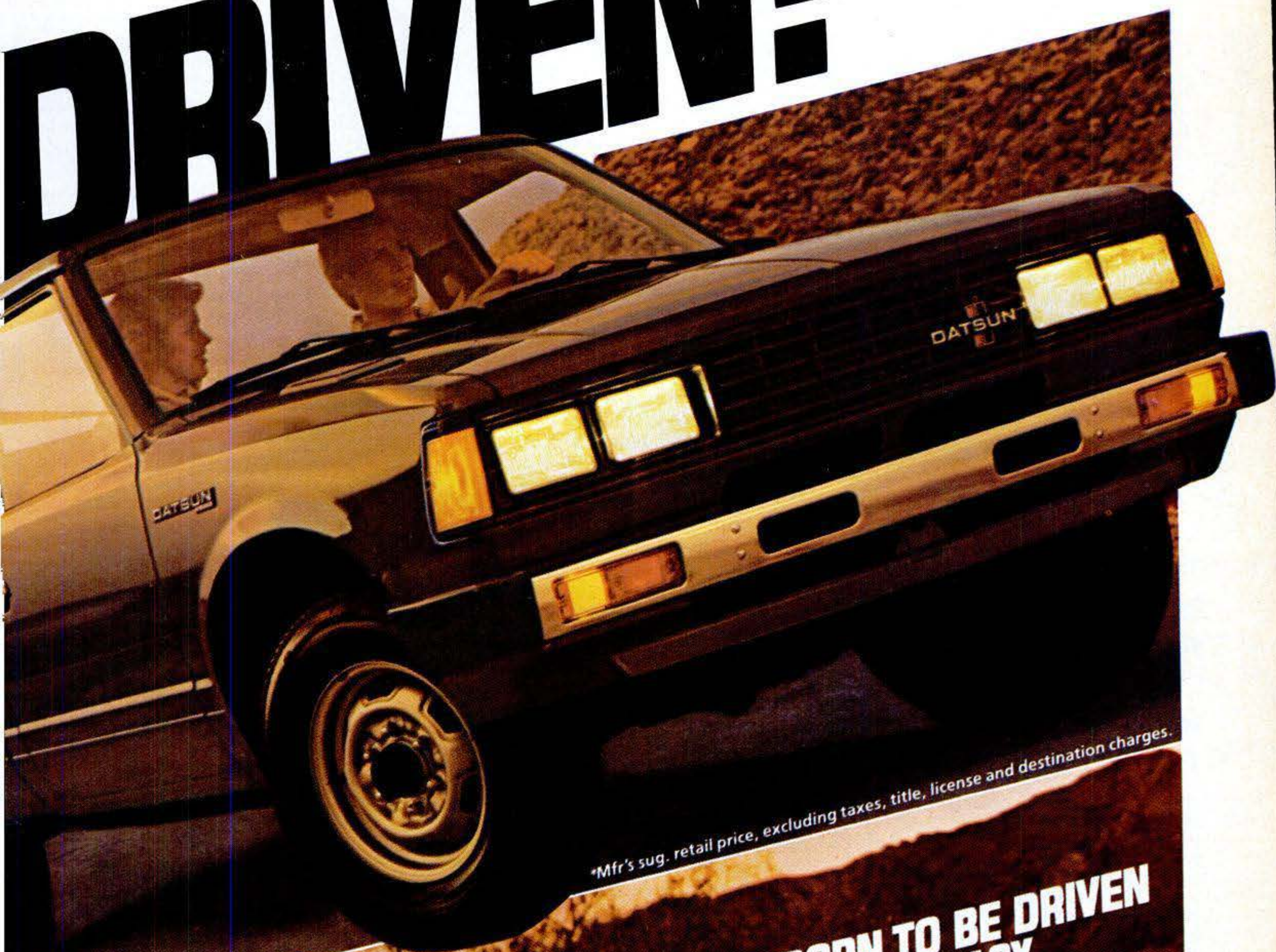
Datsun trucks sold in the past 22 years are still being driven. And driven and driven.

And you can still drive the Li'l Hustler, Datsun's lowest sticker-priced truck, for just \$5858*.

Your money probably never went so far before.



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DATSUN KING CAB[®] 2+2. BORN TO BE DRIVEN HARD AND CARRY FOUR PEOPLE EASY.

You've earned this weekend at Big Bear Lake. But to get there, you've got to beat 80 miles of Interstate traffic and turn left at the hills.

That's driving the Datsun King Cab GL was born for, with 2.2 liters of hemihead power and 2+2 seats of pleasure.

Up front, big buckets that recline to just the right rake. And behind them, room for a couple of friends on jump seats or a "trunkful" of gear under lock and key.

Switch on the stereo (it comes standard), and relax; stretch out in

the comfort you expect in a King Cab—another reason why more truckers drive Datsuns than any other compact truck.

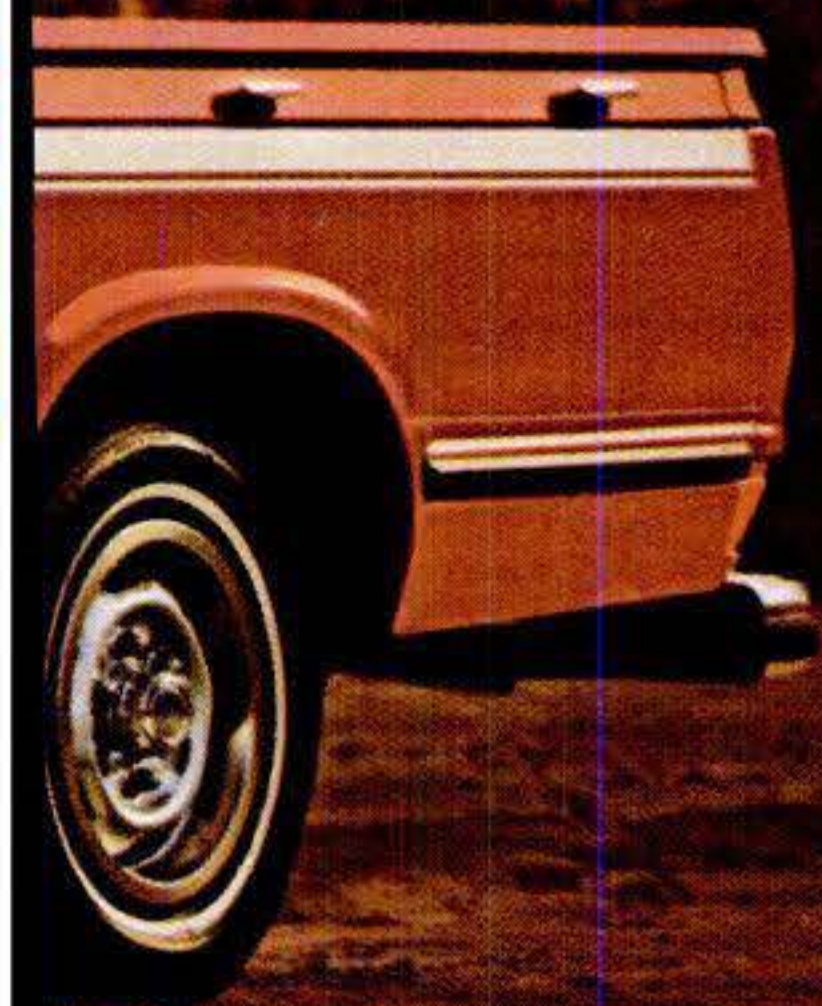
Ready to hit the road? Datsun was born for it.

34 26
EST. HWY MPG EPA EST. MPG

*Use estimated mpg for comparison, with standard 5-speed. Actual mpg may differ depending on speed, trip length and weather. Highway mpg will probably be less. California mpg lower.

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Product of NISSAN



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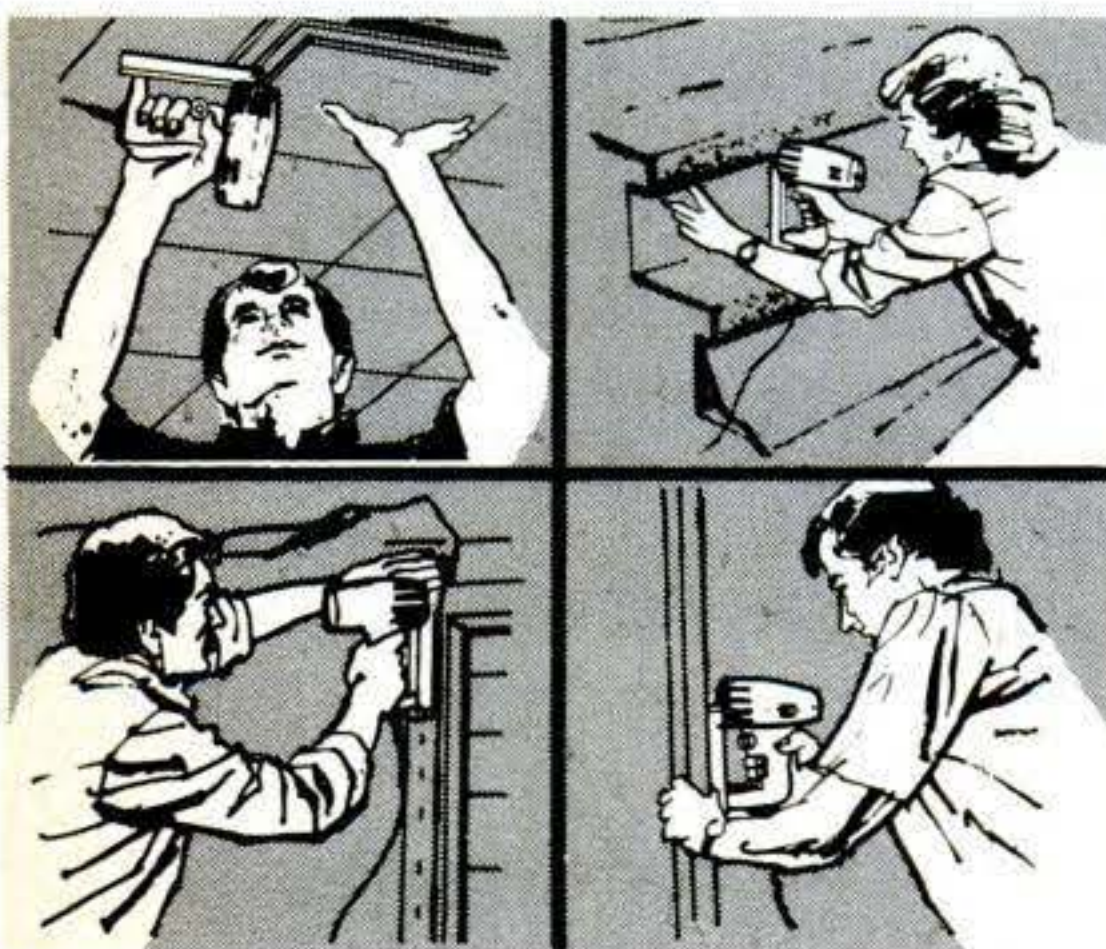
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Yet it packs the staple driving power to penetrate hard woods! Perfect for those man-sized jobs like installing ceiling tile, insulation and weatherstripping! Features on/off safety lock, one-piece solid steel base. Uses 6 staple sizes: 1/4", 5/16", 3/8", 1/2", 9/16" and Ceiltile.



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Science newsfront

[Continued]

sity, Clausthal-Zellerfeld, West Germany, during a joint oceanographic expedition using a research ship and deep-water dredge samplers.

A tough pill to swallow

"Taking your medicine" sometimes presents problems when it comes to swallowing pills and capsules. Dr. J. Ace Brown of Augusta, Ga., offered this down-home suggestion in a recent issue of the *Journal of the American Medical Assn.*: To swallow a tablet or pill, place it in your mouth with a small quantity of water and tilt your head back to wash it down. But don't try the same procedure with a capsule. Because it's lighter than water, it will float toward the front of the mouth and be difficult to swallow. Instead, tilt your head forward. The capsule will float back toward your throat and go down easily.

New solar wing for shuttle

A giant solar-array wing, destined to fly aboard the space shuttle in 1984 to demonstrate the advantages of an innovative design, is being developed for NASA by Lockheed Missiles & Space Company. In the photo at right, the retractable wing is shown fully extended. During launch, the 105-foot-long by 13½-foot-wide wing will be folded, accordion style, into a bundle less than four inches thick that will ride in the shuttle's cargo bay. Once in orbit, the wing will be extended and retracted a number of times to assay its strength and dynamic properties. A special coilable extension mast will house the extension-retraction mechanism.

Solar arrays—collections of photovoltaic cells designed to convert sunlight into electricity for spaceship power—have until now been primarily made with rigid metal structures. But the new wing, developed for NASA's Marshall Space Flight Center and called SAFE (for Solar Array Flight Experiment), is made of Kapton, a flexible, lightweight plastic. And its solar cells are wraparound contact cells that are welded directly to the array blanket. Lockheed engineers say that this printed-circuit approach eliminates heavy adhesives and allows greater flexibility during the unfolding and retracting cycle.

The array consists of 84 panels, but only one of them will be fitted with live solar cells, to reduce the cost of the experiment. With a full complement of cells, the wing would generate 12.5 kilowatts of electric power from sunlight. That works out to 66 watts per kilogram, contrasted with only 20 watts per kilogram characteristic of current spacecraft solar arrays. With new high-efficiency cells, output could reach 75 watts per kilogram.

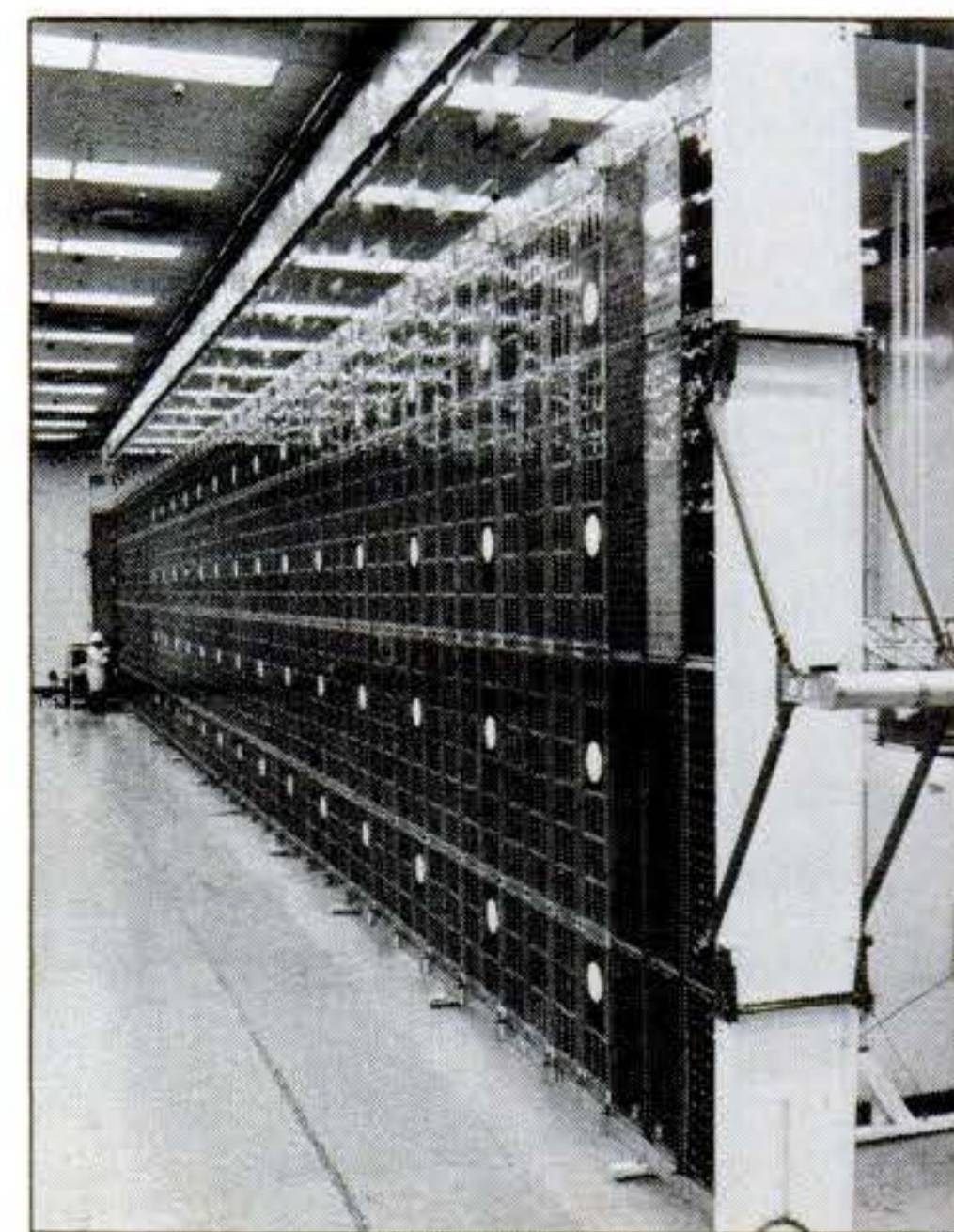
Gasoline demand

For the first time since the Bureau of Public Roads began measuring U.S. highway gasoline use in 1919, energy experts have found a decline in such use for three con-

secutive years, from 1978 to 1981. And a study of transportation fuel consumption between 1973 and 1980, conducted by Oak Ridge National Laboratory's Energy Division, concludes that the forces that led to that unprecedented decline will continue to depress gasoline demand in this country at least through 1985. The four factors cited in the study are: most important, a large jump in fuel prices; the introduction of more-fuel-efficient cars, with an improvement in overall highway fleet economy; a decline in real personal disposable income; and, of relatively minor significance, an increase in the number of diesel cars on the road. According to David L. Greene, leader of the transportation-energy group in Oak Ridge's Energy Division, "the larger factors of price and continued movement to even more-fuel-efficient vehicles should determine future consumption."

Microwave cooking healthier?

Research at Cornell University's Division of Nutritional Sciences is finding that the nutritional value of food cooked in microwave ovens is generally higher than that of food prepared by other methods. The advantage stems from the shorter cooking time required with microwaves: The longer food is heated, in general, the more nutrients are lost or degraded. In one study, Cornell food scientists tracked vitamin C, one of the essential nutrients most vulnerable to destruction during cooking. According to Gertrude Armbruster, associate professor of nutritional science at Cornell, the loss of vitamin C from fruits and vegetables cooked in microwave ovens was as much as 50 percent lower than that encountered in traditional baking and boiling techniques. "The reason," according to Armbruster, "is because less water is required, and up to 70 percent less cooking time is needed. As a result, much less of the vitamin is lost to the water and far fewer nutrients are heat damaged."



WHY THE TIMES ARE RIGHT FOR YOU TO MAKE BIG MONEY SELLING PACE'S SEAMLESS SPRAY...

PART TIME or FULL TIME

*"Every sale brings a
check of over \$1,000"
says Dick Rogers,
President of Pace Products.*

This is the Process and Product whose time has come. Due to shoddy construction, even new roofs are leaking. The Seamless Spray market is a salesman's dream. A vacuum created by the desperate condition of roofs. And the exorbitant price contractors charge to fix them.

Factories, plants, schools, shopping centers, hospitals. In even the smallest towns, you've got dozens of prospects whose roofs need SEAMLESS SPRAY which you'll make available at a small fraction the cost of what they'd have to pay a roof contractor.

Questions everybody asks

Q How much selling experience do I need?

A None whatsoever. Our process is so simple, our program so carefully set up, that common sense and a willingness to tell the SEAMLESS SPRAY story is all you need.

Q Do I have to come into this business with a background in working with important people?

A This is what never ceases to fascinate. We have carpenters, brick masons, small town merchants, insurance salesmen, wagon distributors, little people from all walks of life who enjoy selling the SEAMLESS SPRAY savings!

Q How much money does SEAMLESS SPRAY save my customers?

A It depends on the kind of roof. But you can conservatively estimate that you will save your customer at least 50% and in most cases more than 75% on what he'd invest in a new roof. Example: One school customer recently estimated their savings at over \$28,000. The bigger the sale, the bigger the savings.

Q Why does SEAMLESS SPRAY pay such huge commissions?

A Because you engage in a business where the average SEAMLESS SPRAY order for even a modest roof on a Main Street Building or a school, runs into sufficient

size to support such a salesman's commission. Pace distributors enjoy the biggest commission per sale of any salesmen in Direct Selling. This is the joy of working this program.

Q What about repeat business?

A Here is where the rest of Pace's line comes into play. Once you solve a man's roof problems and save him so much money, he's your friend for life. He then buys our PARK-KING Blacktop sealer—our CONCRETE PLUS for sealing cement areas—our LIQUID METALLIC SIDING and our HYLOZYME Plumbing Conditioner to mention just a few of the fine quality products in our Pace lineup.

Q Who applies SEAMLESS SPRAY?

A In most cases, the customer does this with his own maintenance people. No trained crews are ever needed. We ship the customer the SEAMLESS SPRAY equipment (Worth over \$2,500) on Free Loan. After the job's done, he returns it.



With today's soaring labor costs, this is one of the things that makes SEAMLESS SPRAY selling so easy.

Q What about an investment?

A You can rest easy. There is none! We send your initial kit at our expense—never ask for an investment. We even have a Supply Program that enables you to make extra money.

Q Is Part-Time Selling practical?

A Not only practical, we recommend it. Most of our biggest money makers work less than a total of 5 days a month selling SEAMLESS SPRAY. The size of the sale, the spectacular single order commission is such that this is the perfect part-time selling opportunity.

Q How do I get started?

A Just fill out and mail this coupon. We'll rush you everything you need to get off to a super-selling start. And we'll help you every step of the way.

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O.K. Mr. Rogers, I'd like to make some of the big money that's being made selling Pace Products. Please rush me everything I need to get started. I understand there is no cost or obligation and no one will call on me.

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An expert's choices: solar-energy books, catalogs, and services

By JEFFREY MILSTEIN

I am an architect specializing in passive-solar structures [such as the add-on sunspace in the May '82 issue]. A number of books have been useful to me, so I've made a list of them—the "help-in-print" for do-it-yourself designers and builders.

The Passive Solar Energy Book, by Edward Mazria (Rodale Press, Emmaus, Pa. 18049, \$10.95) is an excellent book, clearly written and well illustrated. It uses a highly developed rule-of-thumb-and-solar-pattern system to help you size solar glazing and thermal masses to prevent too-great temperature swings in a building. One of the best features is a unique set of solar-radiation graphs that you can use to analyze your own site.

Another good book written in simple, clear language is *Passive Solar Energy*, by Bruce Anderson and Malcolm Wells (Brick House, 34 Essex St., Andover, Mass. 01810, \$8.95). This would be a good one to start with if you want the basics. Besides all the principles and rules of thumb, it includes construction details and a directory of passive-solar resources.

Also by Bruce Anderson, with Michael Riordan, *The Solar Home Book* (Brick House, \$9.50) is one I still pick up frequently to check a fact or statistic. It's got lots of ideas on design. There's an excellent appendix with handy information such as insulation values and cost-analysis graphs.

If you find yourself wanting more hard figures on how much you can expect to save with your solar design, get a copy of *Passive Solar Design Handbook, Vol. 2*, by J. Douglas Balcomb (National Technical Information Service, U.S. Dept. of Commerce, Springfield, Va. 22161, \$31.50). It provides quick, simple methods to calculate yearly solar savings as well as more detailed and accurate analyses.

Included: rock-bed performance designs for hybrid passive systems and methods of analyzing their cost effectiveness using the solar-load-ratio method to predict performance. This method is now available on home computers, based on research at Los Alamos Labs. Vol. 3 will be coming out shortly.

The U.S. Government Printing Office (Superintendent of Documents, Washington, D.C. 20402) offers the following low-cost publications: *Passive Design: It's Natural* (No. 061-000-00401-7, \$3.50), a 21-page booklet that provides basic principles; *A Survey of Passive Solar Buildings* (No. 023-000-00437-2, \$3.75), a well-illustrated publication with lots of ideas but not much detail; and *Regional Guidelines for Building Passive Energy Conserving Homes* (No. 023-000-00481-0, \$5.25), which recommends the kinds of approaches to use for 13 different climate conditions. Helpful drawings in this last booklet allow you to grasp ideas quickly; it includes both heating and cooling data.

For information on the nuts-and-bolts side, or "how you actually build it so it works," there are a number of good sources (although they don't always agree on methods):

Solar Retrofit, by Daniel K. Reif (Brick House, \$8.95), gives you construction information and details for retrofitting your home. It includes fundamentals of solar energy, how to make a site analysis, and how to build a thermosiphoning air panel, an attached solar greenhouse, aluminized night shade, and other hardware.

Passive Retrofit Handbook, Solar Applications for Residences (Southern Solar Energy Center, 61 Perimeter Park, Atlanta, Ga. 30341, \$5.95) is an excellent guide for the residential do-it-yourselfer; it's full of lots of big,

clear building details with dimensions, comparisons of materials performance and costs, manufacturers, and rules of thumb.

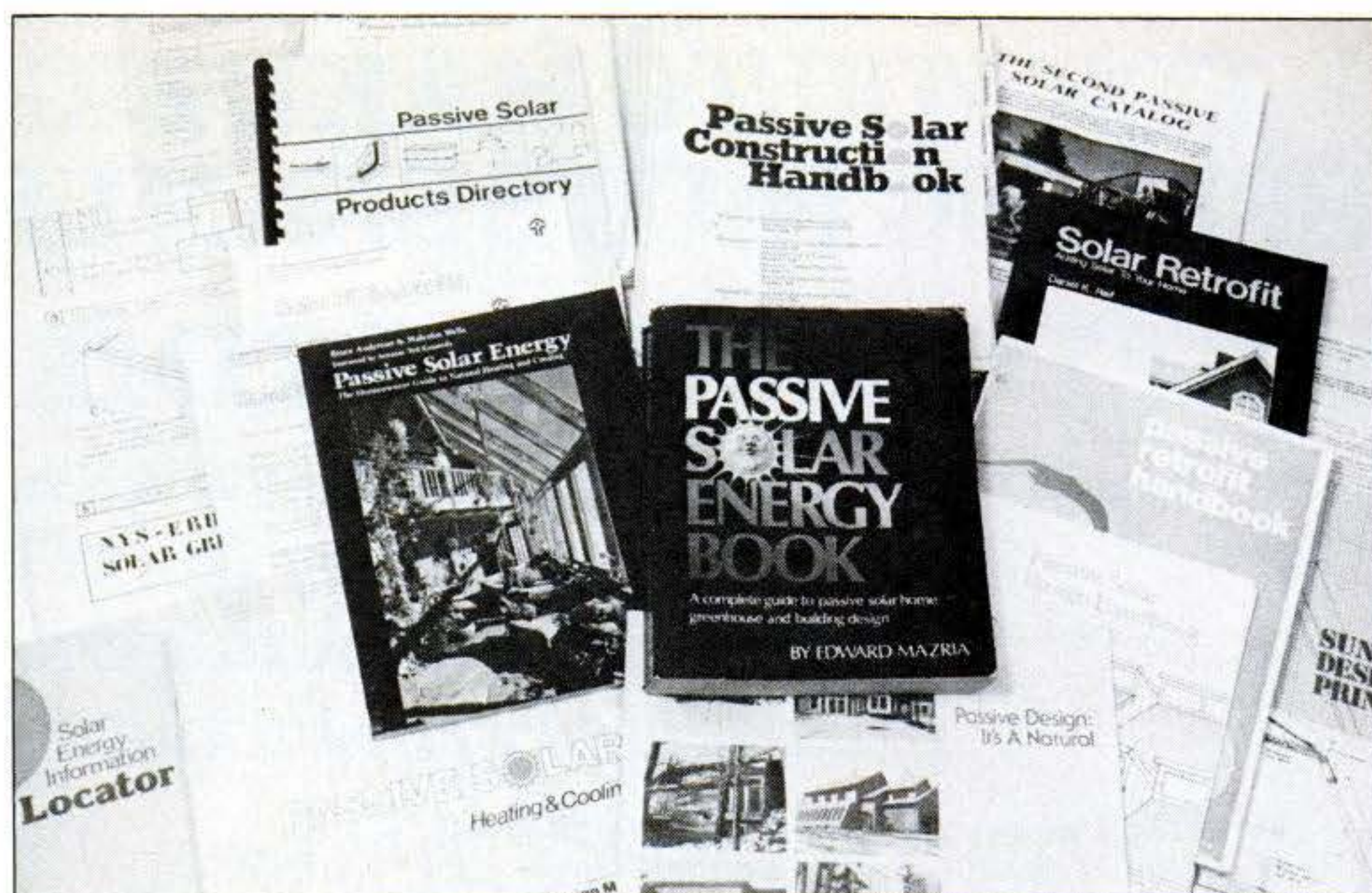
Passive Solar Retrofit, by Darryl J. Strickler (Van Nostrand Reinhold Co., 135 W. 50 St., N.Y., N.Y. 10020, \$10.95), tells you how to analyze your house to determine what to do with what you have. It includes many helpful examples of already built retrofits showing before-and-after photographs and performance evaluations.

Passive Solar Construction Handbook (Southern Solar Energy Center, \$22.45) is chock full of building detail and design fundamentals, but the language seems to be more for architects than do-it-yourselfers. Detail drawings lack dimensions; otherwise, the graphics are good. Architects and contractors will find a lot of meat here.

A new one I have just seen is *Solarizing Your Present Home*, edited by Joe Carter (Rodale Press, \$24.95), a 671-page book chock full of projects (not all of them passive-solar ones). I haven't had time to do more than browse through, but it looks great. It has lots of step-by-step photos and illustrations of such projects as an insulating roller shade and sun porches.

If you want the latest in ideas and research on all passive-solar topics, get the proceedings from the last National Passive Solar Conference, published by the International Solar Energy Society (ISES), American Section, Box 1416, U.S. Highway 190 West, Killeen, Tex. 76541. Contact ISES for the price. These books contain thousands of pages of papers presented on new developments in the passive-solar field (many are highly technical); you could spend years going through them. If you want them you should join ISES, since the cost of

Continued



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Gardening
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Especially for Small Gardens!**

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- **SAVES GARDEN SPACE!** Narrow 14" tilling width allows you to plant your rows closer together. Grow more in less space!
- **EASY TO USE!** With its tines in the rear and engine out front, the "JUNIOR" is so well balanced you can handle it with JUST ONE HAND. Won't shake you to pieces like front-end tillers do!
- **EASY TO TURN & MANEUVER!** Because the "JUNIOR" is light and compact (but strong!) you can turn it and maneuver it in tight places with wonderful ease!

There's much more to know about this wonderfully different and better idea in small garden tillers...like how you can use it to build super rich soil, no matter what your soil conditions...or, how it can help you grow two, even three crops of vegetables where you could only grow one before!

So why not mail the coupon TODAY, and get all the exciting facts about the amazing new TROY-BILT "JUNIOR"...Plus our mid-sized PONY and large garden HORSE Models. We'll include prices, attachments and complete information about our special "OFF-SEASON" Savings discount now in effect!



WHY, for heaven's sake suffer any longer with a tines-in-front type of tiller that has no power to the wheels and shakes you to pieces? And why break your back with hoeing, raking and shovelling? The New TROY-BILT "JUNIOR" makes all your gardening chores faster and easier—increasing your gardening JOY! Send for full details TODAY!

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The BIG JOB tiller...for small, high yield gardens!



"Grow more in less space!"



"No more hand weeding!"



"Turns on a dime!"

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YES! Please send me complete information on the new JUNIOR and all other TROY-BILT Tiller Models ranging from the 5 HP PONY to the 8 HP "PROFESSIONAL" including details on prices and big "OFF-SEASON" Savings now in effect!

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Solar-energy books

[Continued]

publications is less for members.

To keep myself generally well informed on the latest ideas as well as new products, I subscribe to *Solar Age* (Box 4934, Manchester, N.H. 03108) at \$20 a year.

To find a solar product I am interested in I check *Peoples Solar Sources Book* (Solar Usage Now, 450 E. Tiffin St., Bascom, Ohio 44809, \$5). This is a

352-page catalog of products for sale.

For specifics on greenhouses there's *The Solar Greenhouse Book*, edited by James McCullagh (Rodale Press, \$9.95); *The Food & Heat Producing Solar Greenhouse*, by Rick Fisher and Bill Yanda (John Muir Publishing, Box 613, Santa Fe, N.M. 87501, \$8); and *Low Cost Passive Solar Greenhouses*, by Ron Alward and Andy Sha-

piro (Charles Scribner's Sons, 597 Fifth Avenue, New York, N.Y. 10022, \$10.95), a design-construction guide.

For window insulation, there are two good books: *Thermal Shutters & Shades*, by W. Shurcliff (Brick House, \$12.95), and *Movable Insulation*, by William K. Langdon (Rodale, \$9.95).

To find an article on solar energy that you've seen but can't place or to see if one exists on a particular subject, consult the *Solar Index*, Box 6933, Denver, Colo. 80206. A yearly \$18 index to solar periodical literature, it includes articles that have appeared in *POPULAR SCIENCE*, *Solar Engineering*, *Sun World*, *Solar Living*, *Solar Age*, *Alternative Sources of Energy*, *Solar Energy*, *Wind Power Digest*, *Solar Heating and Cooling*, *ASME Journal of Solar Energy Engineering*, *New Shelter*, *Progressive Architecture*, and *Earth Shelter Digest*.

And finally, there are still some freebies around: *Passive Solar Heating & Cooling Design* (Western Sun, 715 S.W. Morrison, Portland, Ore. 97204) is a 48-page booklet on basics.

Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS) has free solar fact sheets and booklets that provide basic information on a variety of subjects, including passive solar, and bibliographies of literature on conservation and alternative energy sources. Call, toll-free, from 9 a.m. to 6 p.m., Eastern time, (800) 523-2929; Pennsylvania: (800) 462-4983; Alaska and Hawaii: (800) 523-4700. P 5

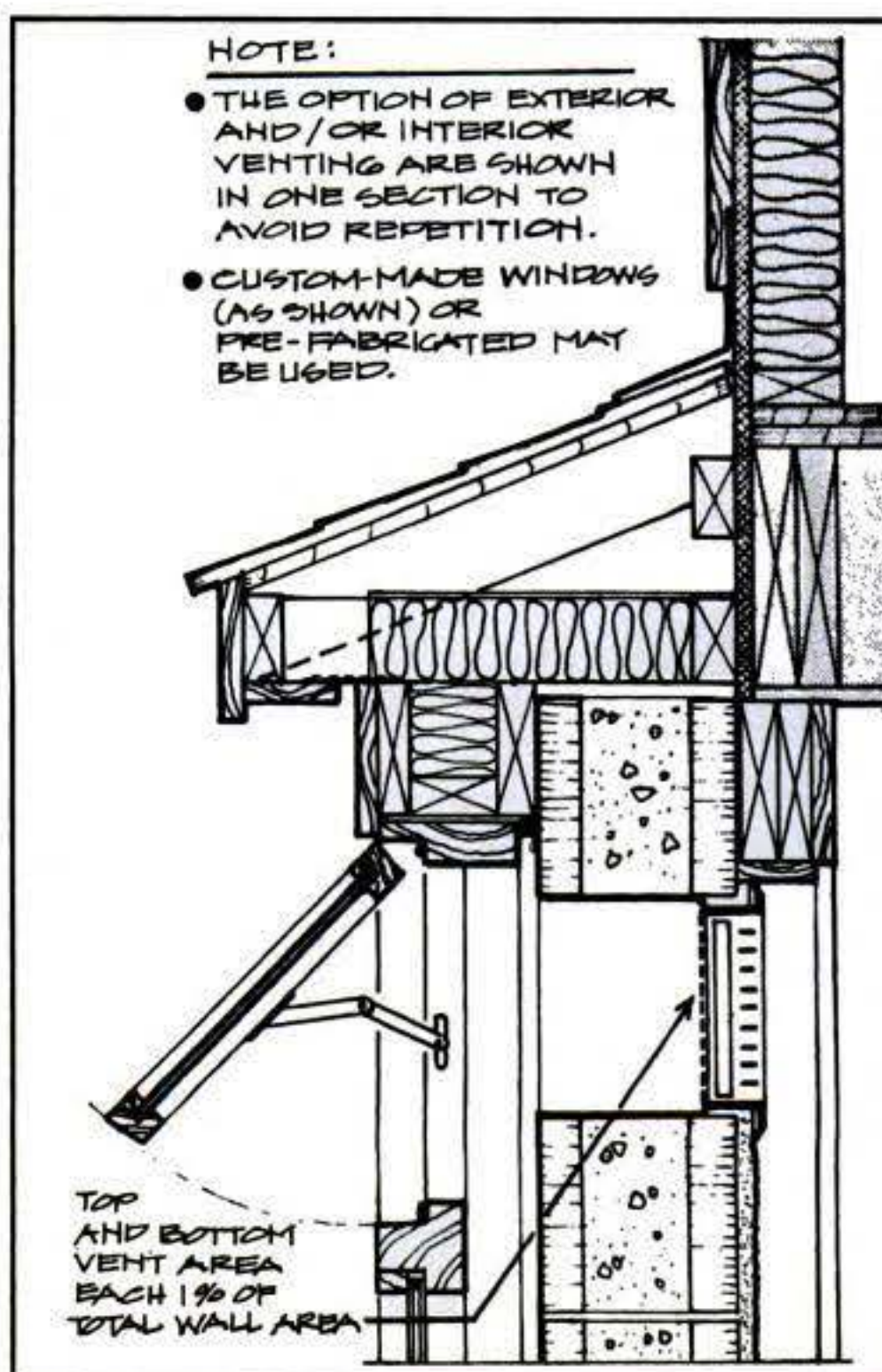
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The Radar Defense Kit

Radar warning. No waiting.

What Could Be Better Than Unbelievable Range?

By now, you've probably heard some tall sounding stories about how far away the ESCORT® radar warning receiver picks up radar traps. You know, the ones where they talk in miles instead of car lengths. The stories go on to say that ESCORT's superheterodyne receiving circuits provide as much X and K-band warning as you can possibly use, and then some. If you've never used an ESCORT, they may seem pretty far fetched, but most of them are true. Over hills, around corners, and from behind.

Car 54 Where Are You?

Maximum detection range is wonderful, but it's far from the whole story. In some ways, radar detectors are like smoke alarms; you want to make sure that you don't miss anything, but you don't want a lot of false alarms. ESCORT won't disappoint you. Beyond that, when a smoke alarm sounds off, the most pressing thing on your mind is: Where is the fire? Is it ahead of you, behind you, above you, or below you? In the same room, or at the other end of the house? Your senses can help you find fire, but, on the highway, you can't feel or smell radar. ESCORT is your sixth sense.

Hearing Is Believing

ESCORT reports its findings straight to your ears in a way no other detector can match. Its vocabulary includes a Geiger-counter-like pulsating rhythm that relates radar intensity in a smooth, natural, and intuitive manner, making it easy to sense the distance to radar. It can tell you if radar is ahead of you, behind you, or even traveling along with you in traffic. ESCORT also speaks different languages for each radar band. Since the two bands behave differently, the distinctive tonal differences eliminate surprises. You'll even be able to tell "beam interrupter," "trigger," or "instant-on" type radars from other signals just by the sounds they make. Ditto for radar burglar alarms and door openers. ESCORT has a lot to say, and we've developed a new way for you to get acquainted quickly.

Play It, Sam

ESCORT's instruction book contains a wealth of information. Actually, it's the ESCORT user's Bible. But, the quickest way to become fluent in ESCORT's language is to play the Radar Disc on your stereo turntable. You'll hear firsthand how to interpret what ESCORT tells you in a number of situations. We now include this special Disc with every ESCORT so you can take a test drive as soon as you open the box.

No Stone Unturned

The ESCORT Radar Disc is the latest addition to a long list of standard features. We don't scrimp on anything. Here they are: ■ Patented Digital Signal Processor ■ Different Audio Alerts for X or K Band Radar ■ Varactor-Tuned Gunn Oscillator tunes out false alarms ■ Alert Lamp dims photoelectrically after dark ■ 1/64 Second Response Time covers all radar ■ City/Highway Switch filters out distractions ■ Audio Pulse Rate accurately relates radar intensity ■ Fully Adjustable Audio Volume ■ Softly Illuminated Signal Strength Meter ■ L.E.D. Power-On Indicator ■ Sturdy Extruded Aluminum Housing ■ Inconspicuous size (1.5H x 5.25W x 5D) ■ Power Cord Quick-Disconnect from back of unit ■ Convenient Visor Clip or Hook and Loop Mounting ■ Protective Molded Carrying Case ■ Spare Fuse and Alert Lamp Bulb.

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BMWCCA Roundel: . . . "The ESCORT is a highly sophisticated and sensitive detector that has been steadily improved over the years without changing those features that made it a success in the first place . . . In terms of what all it does, nothing else comes close."

Playboy: . . . "ESCORT radar detectors . . . (are) generally acknowledged to be the finest, most sensitive, most uncompromising effort at high technology in the field."

Autoweek: . . . "For the third straight year, no manufacturer has bettered the ESCORT's sensitivity . . . the consistent quality is remarkable."

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Snow chokes his truck

Whenever I drive to work in a snowstorm my 1978 Chevy pickup with 250-cu.-in., six-cylinder engine poops out on me, and black smoke comes out the exhaust. After stopping for a few minutes it goes along okay for a while. I believe the automatic choke closes up—but why it does is a mystery to me.

Willis A. Reil, Gardnerville, Nev.

The black smoke says the mixture is rich if the engine is operating normally. Pull off the air-cleaner assembly to see if the choke is open. If it is, the throttle plate probably iced up because the carburetor hot-air system isn't working. The system uses a vacuum motor in the air cleaner that keeps the heat on until carburetor air reaches 115 to 118 deg. F. This, of course, would prevent icing.

Does turbo help mpg?

I've heard that a turbocharger can give better gas mileage. But it seems to me that adding one would give more power on demand for acceleration or high speed and do little for normal cruising.

Donald G. Jones
South Burlington, Vt.

Turbos don't really help gas mileage as they are now used. In specific situations there could be some gain. At full throttle, if that type of power is needed from a small engine, the thermal efficiency goes up and, therefore, so does the mileage. If done right, it would help across the board.

Windy bird

The wind noise is terrible on the highway in my 1982 Pontiac Firebird. The service center says it's the design of the car and nothing can be done about it. Do you have any suggestions?

Debbie Gort, Mankato, Minn.

With the windows up and adjusted with no air leaks, it's not that bad for today's cars. The rest of it is the way it is.

Compact spare causes wear

My new car is equipped with one of the compact spare tires now supplied. It's always been my belief that the drive wheels should be evenly matched, and I wonder if one large wheel and one small wheel will cause wear on the differential if I drive any distance.

Gordon Pratt, Riverside, Calif.

It's a problem on limited-slip differentials

and will cause plate wear, but I don't think four or five miles would ruin it. On open axles it's not too bad.

Cockpit spark adjustment

I have a 1979 Volare (Slant Six engine) and can't get rid of spark knock unless I run on premium gasoline or gasohol. The car has 20,000 miles on it.

Bernard Bancuk, Grand Rapids, Mich.

Have someone work on the distributor advance. Water injection will calm it down, but you'll pay later. Units for adjusting spark (from the driver's seat) are now available, and Autotronic Controls Corp. (6906 Commerce St., El Paso, Tex. 79915) builds a good one.

Old diesel worries

I'm the worried owner of a 1980 Olds Toronado diesel. It's a pleasure to drive, but after 14,000 miles the injection pump went. I got the water-in-the-fuel song, but I've always had a Racor water separator. How long do you think the new pump might last?

Timothy B. Long, Brooklyn, N.Y.

The pump is never going to be a contender for any engineering prize. But it may be great for what it costs.

What car to buy?

I bought a Chevrolet Cavalier after three VW diesels in a row. It's reasonably satisfactory, but the engine pings on 93-octane gasoline and performs very poorly on the recommended 87-octane fuel. The highway mileage is 20 percent less than advertised; I could always get more than advertised with the VW's. Where do I look for a mid-size car with low drag and a moderate-displacement engine?

Carter E. Hewitt, Washington, Ill.

The most common question asked me is what car to buy. I'd like to recommend American, but with the 1981-'82 emissions deal I can't, in good conscience, recommend a thing.

Where to put grease?

When replacing wheel bearings some mechanics say that when the grease gets hot it tends to push away from bearings; others say the opposite. Where should it go?

Jonathan Smith, Bainsville, Ontario

I think you should put it where you want it in amounts considered best, but the biggest issue is to use the correct type of lube
Continued

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*All who wish to apply for a watch
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NEW YORK—One million famous LCD Quartz calendar watches will be sold as part of a publicity campaign for only \$4 apiece to the first one million persons who apply in writing to the company before Midnight, February 28, 1983.

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"Say, Smokey—"

[Continued]

for a specific job. Caution: Don't guess. Use the manufacturer's recommendations for your car's make, model, and service classification.

Rear brakes lock up

I'm having a problem with my 1980 Citation's rear brakes locking up before the front in hard braking and on wet pavement. My dealer says he can do nothing more.

Chestly D. Osier Jr., Midland, Mich.

This may sound stupid, but put 100 to 150 pounds in the trunk and then find a dealer or brake man who can get your system balanced out before you get in trouble. Very possibly your front brakes need some work to get them in ahead of the rear. The car should have been recalled.

How much is too little?

How many quarts of motor oil are needed to avoid engine damage in a four-quart-capacity crankcase?

Richard Rocco, Hopatcong, N.J.

The real answer is to never lose oil pressure, and it depends on how hard you drive. For normal driving, about 1½ quarts could do it; for hard driving, two to 2½ quarts are needed to compensate for cornering and braking.

Van likes being high

My 1974 ¾-ton Ford van with 302 V8 engine and three-speed standard transmission gets an average of 15 mpg on regular gas here in Kansas at an altitude of about 1,000 ft. On a vacation in mountain country my mileage increased to 17 mpg at 7,000 to 8,000 ft., but the engine would lug in third gear at about 15 mph compared with 10 at lower levels. I'd accept the loss in power for the gain in mpg. How can I get that increased mileage?

Leonard Bennett, Wichita, Kan.

At the higher altitudes you ran effectively at a lower compression ratio and your air-fuel ratio was richer. To duplicate that at sea level, drop the compression and enrich the mix about five percent.

Wonders about ignition specs

When the timing specs say 10 deg. BTDC, what driving speed is this set at—25 to 30 mph? When the spec reads 10 deg. BTDC and you advance it, the engine speeds up. Isn't this getting better gas mileage? At highway speed, is the 10-deg.-BTDC, which was set at idle speed, the best gas saver? Is there such a thing as setting the timing for city and highway driving?

Paul Remillet
Wilton Manors, Fla.

Most spark settings are set at a factory-specified idle speed with the vacuum disconnected. Advancing is no real correction. Most cars have ported spark at idle (no vacuum) for emissions reasons. As a rule, factory specs are best for mileage.

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To your last question: No, most cars now carry as much as 55-deg. spark advance at part throttle, light loads.

Stumbling Civic

My 1981 Honda Civic with 1,500-cc engine warms up okay but stumbles on takeoff unless I use excessive rpm and slip the clutch. The dealer says this is an inherent problem.

Fred Grant, South Saint Paul, Minn.

There's no low-end torque. Any fixes I could suggest won't allow the car to pass emissions tests. It needs more compression, more cam, more fuel, a different combustion chamber, lower gear, less carburetor hot air, less manifold heat, etc. They gave up too much for mileage and ended up with El Rubber Bando.

Old tricks not for new cars

My 1981 Ford Fairmont requires no-lead gasoline, but my older cars always used leaded gas. I've always thought that the lead helped valve life. Should I use an additive at regular intervals to keep the valves from going bad?

Harry Whitman, Shawnee Mission, Kan.

If you use additives, you're probably going to knock out your catalytic converter and screw up emissions. On a new car, experimenting and playing our old tricks

are likely to cause trouble. For example, the oxygen sensor sniffing oxygen content could have a fatal heart attack figuring out what the additive was; the same for the computer trying to decide on an air-fuel ratio.

Transmission spits

My 1981 Mazda GLC with five-speed manual transmission is venting fluid from the transmission despite a factory fix. Is part of the problem Mazda's use of automatic-transmission fluid in this unit? How long will the five-speed last with this fluid as a lubricant?

Walter N. Leneau, Charleston, S.C.

Don't worry about the lube; for your application I prefer it. Venting is either the result of the vent position or pressure. A location change is the easiest fix and height gives the biggest relief. Some lubes expand and foam more than others; sometimes keeping the same specs but using a different product will help.

Trembling truck

My 1981 Datsun King Cab has a small vibration like a wheel out of balance at 45 to 65 mph. The vibration seems to come from the rear end, because the steering wheel is smooth.

David Davidson, Roseville, Calif.

Get a temporary tach on it, then go

through the gears to see if the vibration is rpm or speed related. If it's rpm, the engine's the cause; if it's speed, the drive line—wheels, tires, or drums—is the problem. The drive line can be balanced but be out of phase at the joints. Motor mounts and exhaust resonance can cause vibration, and that should be rpm and torque related. The air conditioner or alternator can cause resonance—again rpm. If the engine itself is vibrating, the problem could be balance, too much spark advance, lean air-fuel ratio, or too much EGR.

Shield does double duty

My 1980 Ford Van has a front deflector shield that does its job and keeps the windshield clean, but is it hurting my gas mileage?

Paul Travis, Urbana, Ill.

No. In fact, I'd say it helps a little.

Each month, Smokey Yunick answers questions on cars—family cars, high-performance models, and racing vehicles. Got a problem? Send it to: "Say, Smokey—", POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters that are not selected for publication.

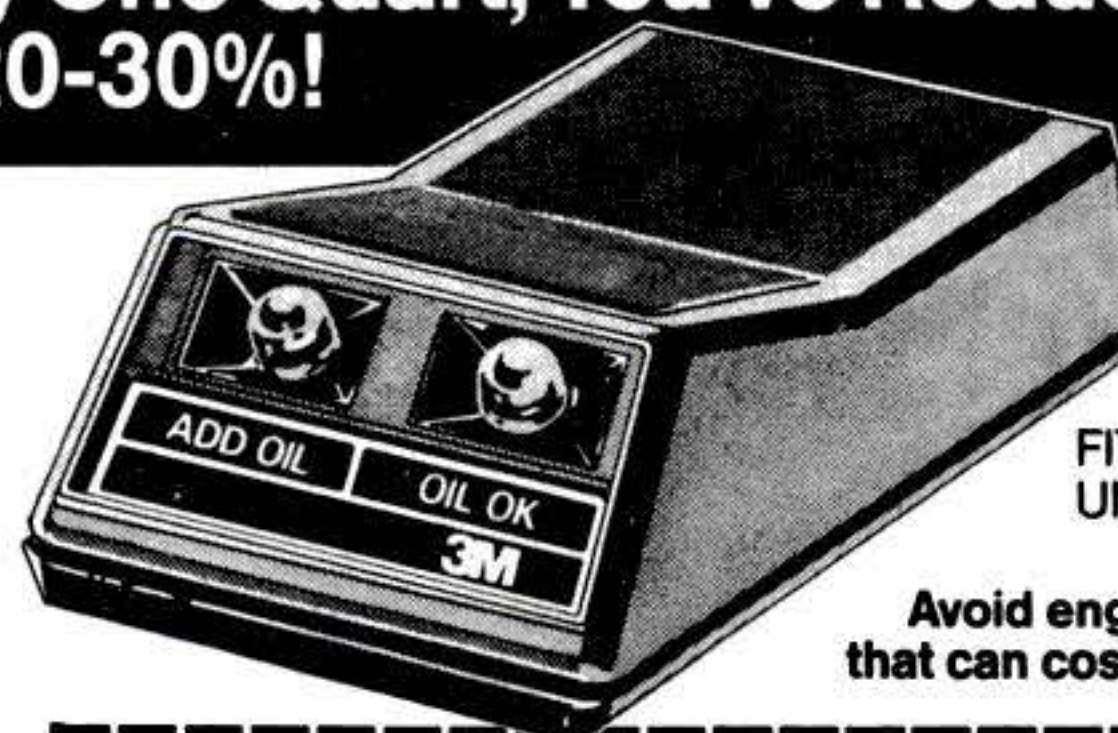
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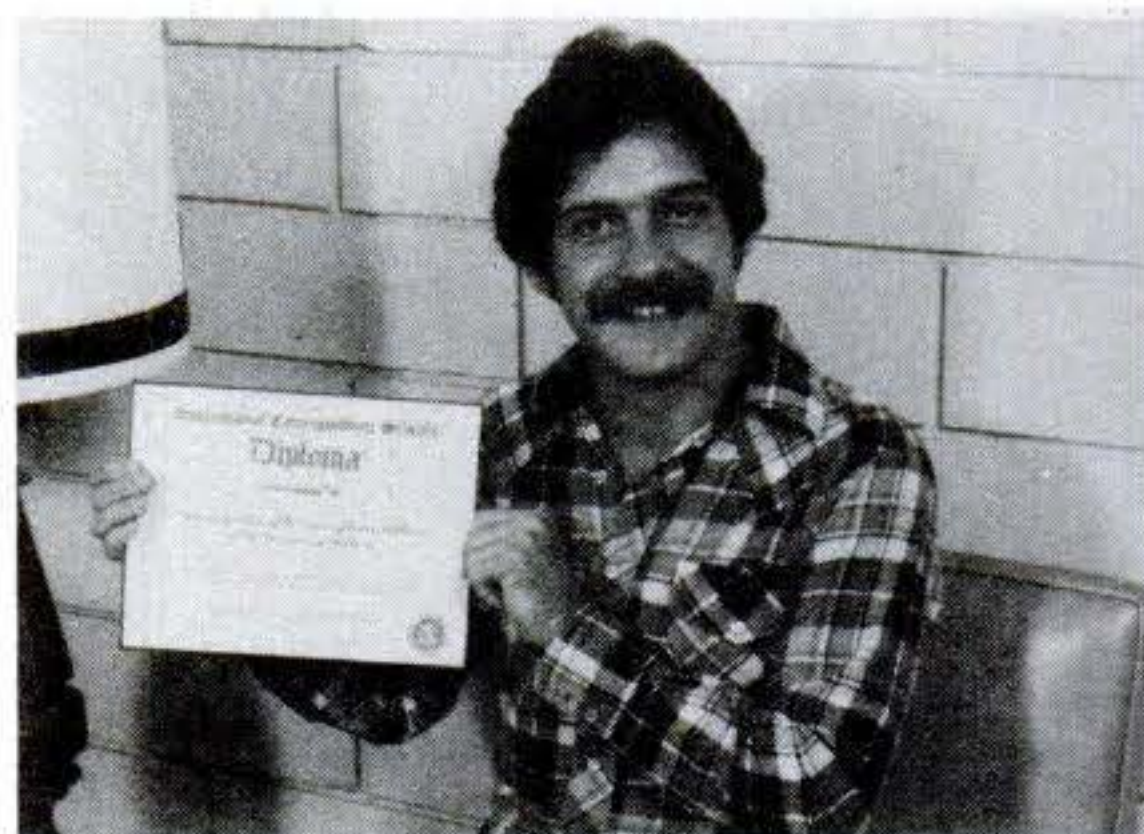
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Wood stove burns smoke, too

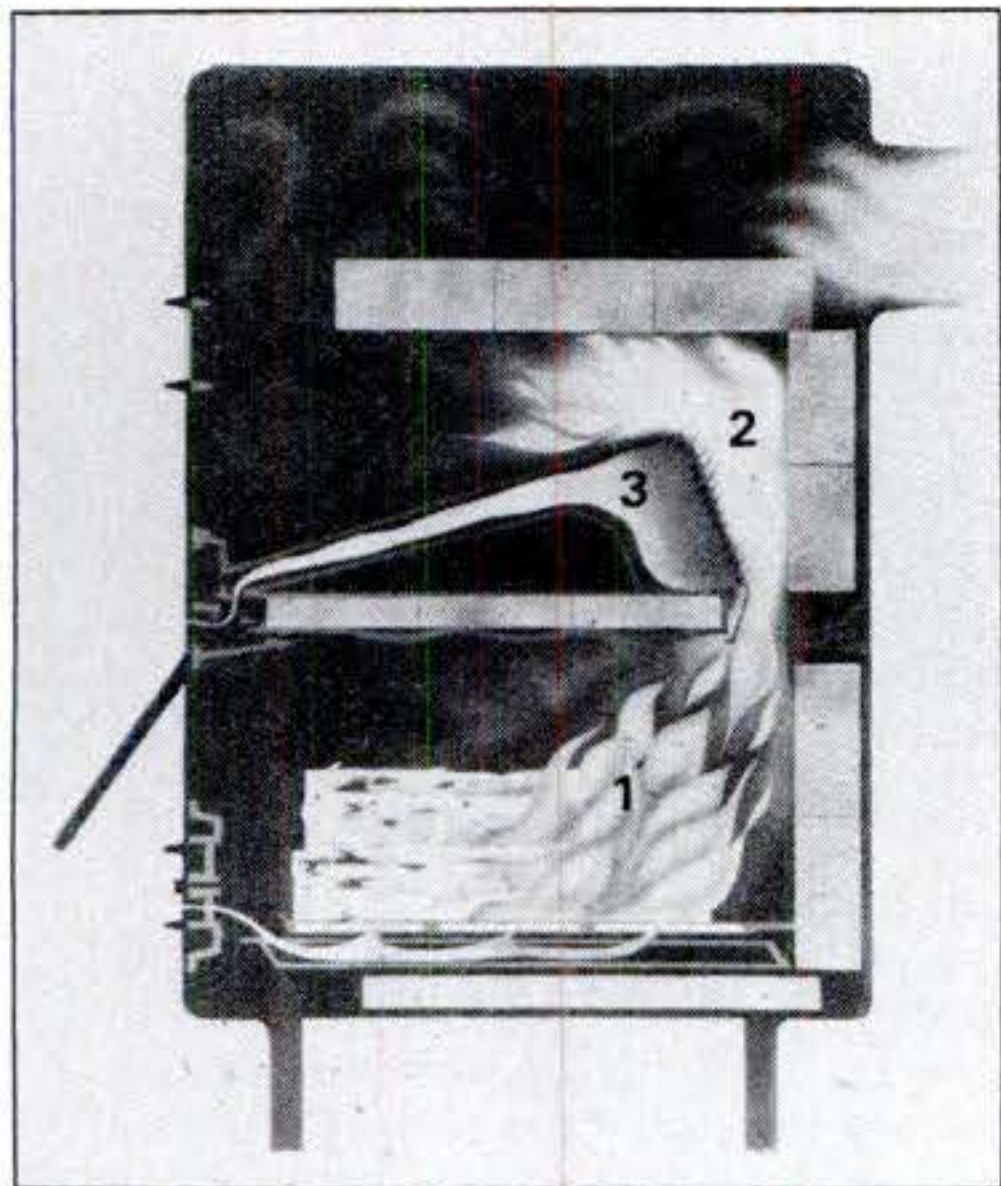
Start a roaring fire in the Turbo 201, then stroll outside and look up at your chimney. No smoke. That's what you'll see—or won't see, promises Jøtul.

The venerable Norwegian company, which has introduced only four new stoves since 1942, took three years to develop the Turbo 201. It burns smoke as well as wood. A number of today's wood stoves use catalytic converters to consume the wood smoke [PS, Jan. '82]. Jøtul does it with a unique stove design. Heavy insulation and an unusual, ramp-shaped heat exchanger (see diagram) combine to make the stove 70 percent efficient, according to Jøtul. You get the same amount of heat from much less wood, saving money—and labor.

Even more important, the stove is safer than most airtights, Jøtul claims. Burning most of the gases before they reach the chimney reduces fire-causing creosote deposits.

According to tests performed by Shelton Energy Labs in Santa Fe, N.M., the new Jøtul stove produced 2.5 times less creosote than comparable wood stoves.

Jøtul USA (Box 1157, Portland, Maine 04104) sells the stove for \$995. —Susan Renner-Smith



Two stoves in one: Jøtul's 201 burns wood conventionally in its primary combustion chamber (1). In the secondary combustion chamber (2), air rushes from the multiple ports of a heat exchanger (3) to ignite smoke rising from below. When all gases are consumed, burning charcoal in the lower chamber provides heat.

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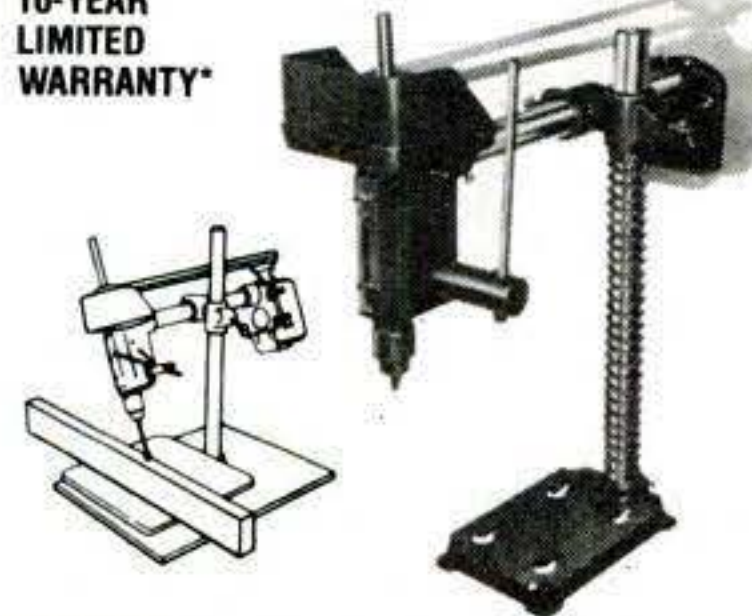
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DETROIT REPORT

By JIM DUNNE



Smaller Caddy?

You bet. Next year the luxury-car nameplate will adorn a mid-size, front-wheel-drive chassis that will have a transverse V8 under the hood. The new car has a 12-in.-shorter wheelbase and 22-in.-shorter length than current de Villes, so traditional Cadillac big-sedan buyers are in for a shock. Prototypes are already running up the miles getting this newest C-body ready for production (photos, above).

In appearance, it's easily recognizable as a Cadillac, with the bright rectangular grille and thin, upright taillights. But there is a lot of GM's A-body in the styling, too. At first glance it's difficult to tell the difference between the new car and the present Buick Century. But with a wheelbase of about 108 in. and an overall length of just under 200 in., it's longer by three in. at wheelbase and 10 in. bumper to bumper. One big surprise: Instead of the projected aluminum V6, Cadillac will have its exclusive 250-cu.-in. V8 under the hood.

The overall styling theme is one of boxy conservatism with little of the new trends toward extreme aerodynamics or wedge shapes. The shrunken Caddy seats six,

but the three front-seat passengers will have to be very friendly. Look for Cadillac to sell a large proportion with individual seats up front. Mechanical details include an independent rear suspension similar to that in the Eldorado, air shocks that adjust automatically when heavy loads are carried in the rear, and the latest in electronic instrumentation. This GM C-body will be shared with the Olds 98 and Buick Electra. Reportedly, Cadillac will not discontinue production of the current de Ville body when the new car goes into production but will continue that model until demand switches to the new type.

Corvette quandary

After the immediate and overwhelming approval of Camaro's radical styling changes, Chevrolet officials are fretting about the moderate styling changes in store for the 1983 Corvette. Even though the new sports car is the first complete mechanical overhaul in the line since 1967, styling does not appear much different from the present car. But it's too late to do anything drastic at this point. The dies are set, and no change will take place

for at least three more years, if then. Chevy is banking heavily on performance and handling to enhance the reputation of the new Vette. With a chassis 600 to 800 pounds lighter, completely new front suspension, and a huge 351-cu.-in. V8 engine, Chevrolet insiders are claiming that the Corvette will again rule many race courses, making it worth the projected 1983 list price of \$24,000.

Toronado shrinks

Prototype "mules" (unfinished testing versions) of the 1984 model are now undergoing power-train tests at GM proving grounds, so the size of the car is set even though styling is not. What you will get in the Toronado package is a front-drive coupe that is just bigger than the current GM J-car line—Firenza, et al. This is the GM E-body that will be shared with Riviera and Eldorado. The three luxury coupes will undergo probably the most drastic change in size and appearance of any recent GM redesign. Observers look for a 25 percent weight loss in these models, from the current 4,000 lbs. to less than 3,000. The engines will be V6's set sideways, similar to the J-car power-train layout. While the mules are not styled for production, you do get some hint from their shape as to what the final car will look like. Curved lines in the belt area replace the relatively straight lines of present cars. The long hood will slope downward severely, and the trunk outline will be more rounded. The rear side glass will be about three times the size of that in present cars as GM stylists attempt to "open up" the interiors, making them appear larger to passengers.

Getting it right

That's the word from AMC to explain the delay in introduction of the new generation of Jeep models, code-named the XJ. The company has not been satisfied with test results up to now and wants to make certain the model is fully proved before it's committed to production. The XJ, which replaces the Cherokee in the Jeep lineup, was originally set for introduction this spring. The delay will move it back to next fall, when it will make its appearance along with the rest of the 1984 car models. The XJ features four-cylinder and optional V6 engines, smaller size than the Wagoneer, unit-body construction, and completely new styling.

A place for the flywheel

VW uses a computer to turn off its innovative stop-start diesel in the 1983 fuel-economy champion, Rabbit. But there are other ways of doing the job. One is to use a flywheel instead of the electric starter to get the engine going after a stop at a light or busy street corner. The benefit is less wear on the starter and a smoother transition from a stopped to a running engine. Another approach—from Japan—is to cut power to two cylinders when an engine is idling for a couple of seconds, then return to all four cylinders when acceleration is needed.

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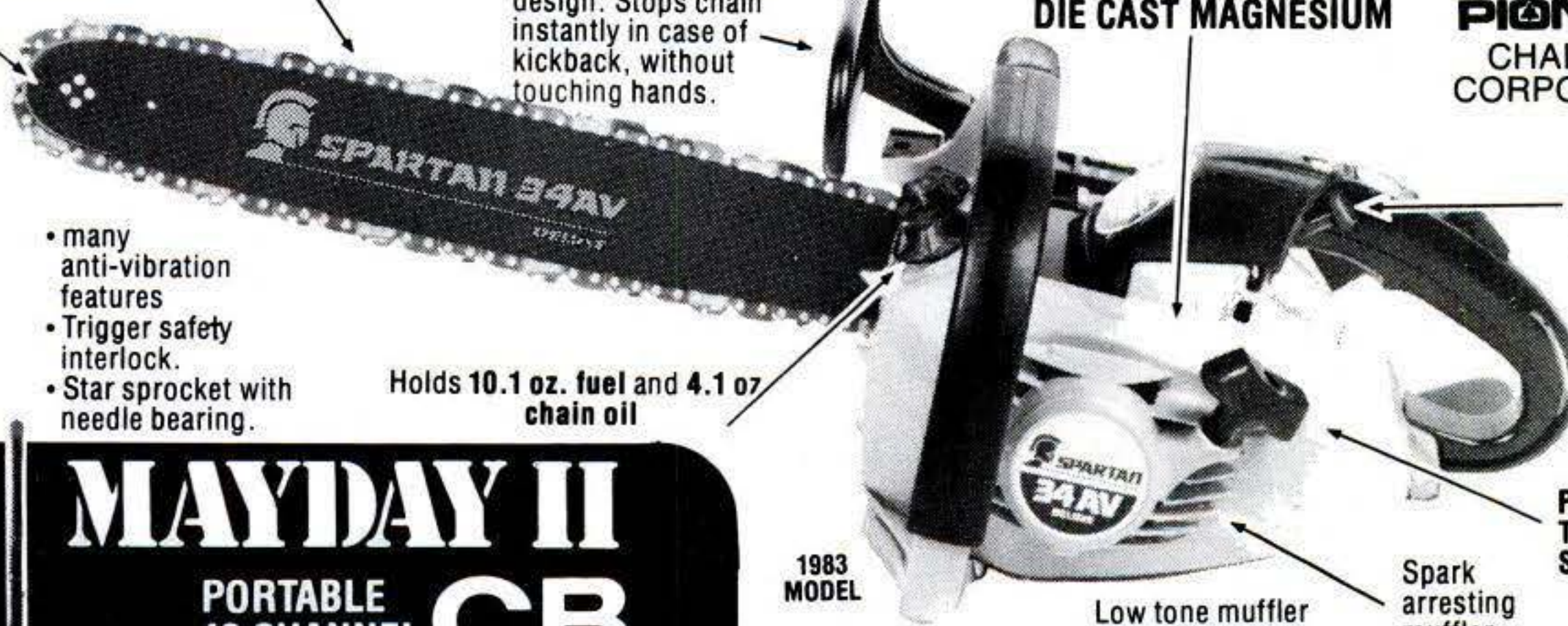
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1983 MODEL



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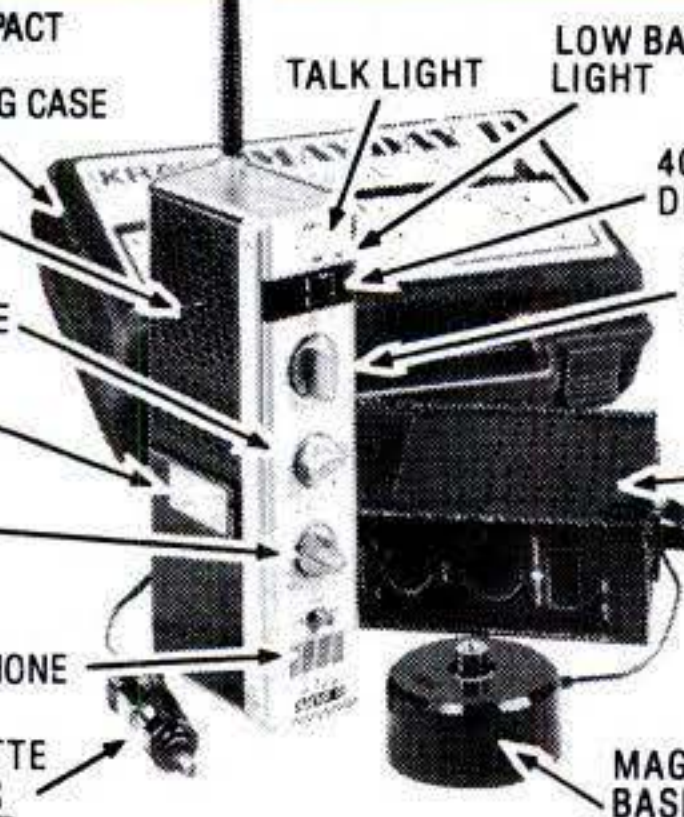
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By **JIM DUNNE**
and **JACK KEEBLER**

PHOTOGRAPHS BY GREG SHARKO

U.S. mpg champs

—they're quicker
and quieter

Ten years ago gas was cheap. The average driver looked at 20 mpg as above par. Only boring, low-powered imports were capable of 30 mpg. Today, with smaller, lighter cars, better small engines, and manual transmissions, there are a dozen or more American-made models that easily top 40 mpg—and approach 60 in EPA tests.

We selected six mileage leaders from the five domestic manufacturers for a close look at what you can expect besides economy when driving fuel-saving champs: American Motors' new Alliance, Chrysler's renamed Plymouth Turismo, Chevrolet's Chev-

Continued

FORD ESCORT



VOLKSWAGEN RABBIT DIESEL



AMC ALLIANCE



PONTIAC 2000



PLYMOUTH TURISMO



CHEVROLET CHEVETTE DIESEL



Come to Marlboro Country.

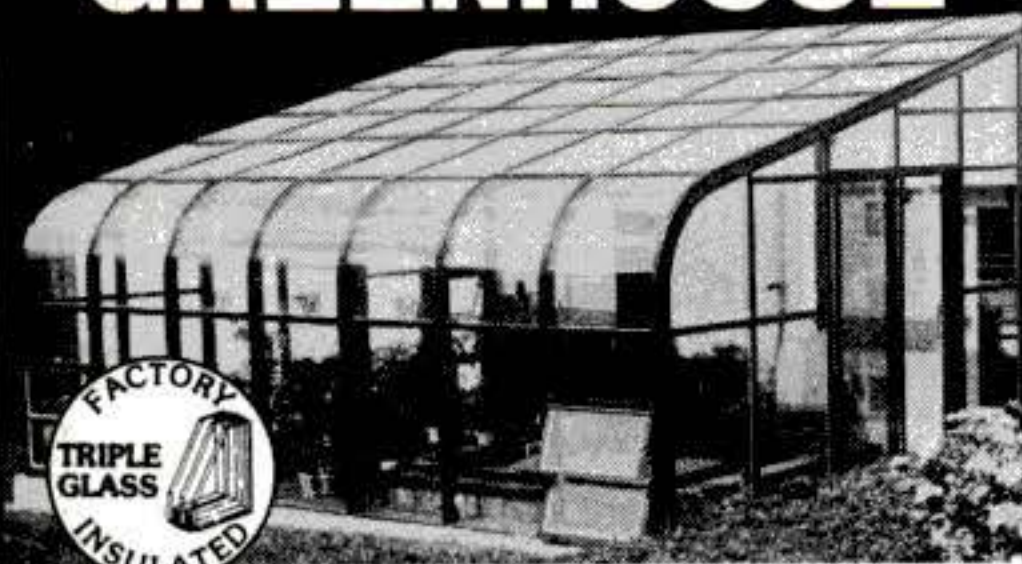


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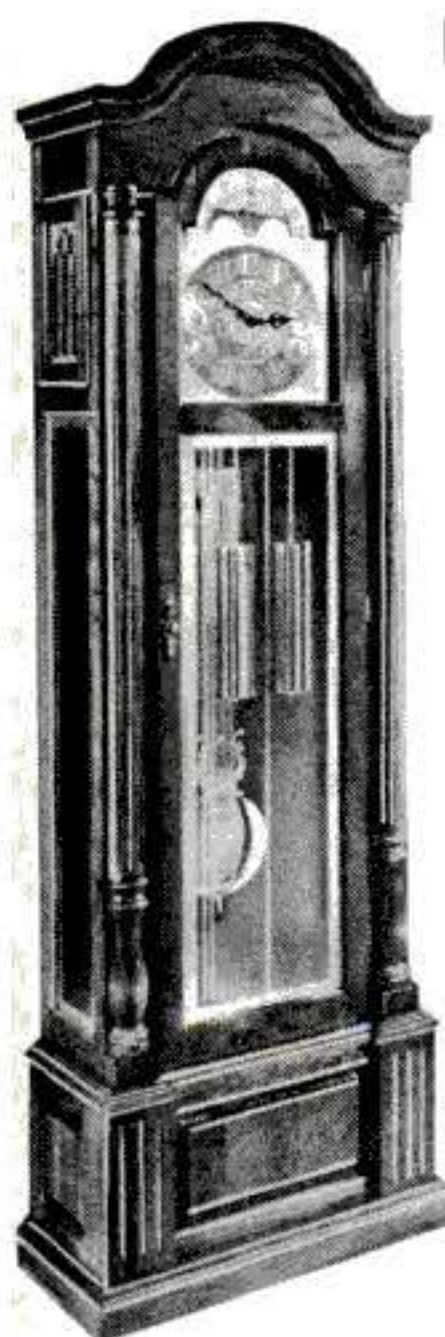
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PS car test & driving report

PS ratings— test report in a nutshell

The ratings are based on test results and measurements. Results should be read with the understanding that they reflect tests only on our sample cars. An excellent rating is 5 points; very good, 4; good, 3; fair, 2; poor, 1; very poor, 0.

	AMC Alliance	Chevy Chevette diesel	Ford Escort	Plymouth Turismo	Pontiac 2000	VW Rabbit diesel
Acceleration	2	0	4	4	4	0
Braking	2	3	2	2	3	3
Handling	4	4	3	3	4	4
Maneuverability	5	5	5	5	5	5
Quietness	4	0	1	1	2	1
Roominess	3	3	3	3	3	3
Vision	5	5	5	4	5	4
Entry/exit ease	3	4	3	4	4	3
EPA economy	5	5	5	5	5	5
Ride comfort*	3	2	2	2	3	3

*Authors' opinion

ette diesel, Ford's Escort, Pontiac's 2000, and the two-time top economy car, Volkswagen's Rabbit diesel. (Next month we'll report on six of the most economical imports.)

Buying an economy car used to mean settling for the stripped version of the vehicle. Not anymore: Most of these cars can be fully decked out with a great variety of equipment and comfort features.

Also, unlike economy cars of the past, the new models delivered outstanding fuel economy in *real-world* driving conditions. Our PS steady-speed 55-mph test proved that all of the cars will top 30 mpg on the highway, and the Chevette diesel easily hit 40. The keys to savings are lightweight body shells, small engines with electronic controls or fuel injection, and well-chosen manual-transmission gear ratios.

Today's economy shopper has a wider and better selection than ever, but there are many considerations that will narrow the final choice. Some fuel-pinching models aren't available with such power-stealing extras as power steering and air conditioning. Also, diesel engines don't provide the performance most drivers are accustomed to, although our performance tests show major improvements over similar models sold last year. Volkswagen and Chevette, with their foreign-built diesels, are about four seconds faster in zero-to-60-mph tests than their 1982 counterparts. This year's gasoline-powered cars are also

quicker in some cases. Finally, a manual transmission with overdrive is usually a must for getting the best out of these high-efficiency types.

Generally, the '83's are quiet and pleasant to drive, and even the most starkly equipped models are comfortable and attractive.

AMC Alliance

Alliance scored the highest grade ever for a subcompact in our noise test. Its rating in our "nutshell" box was two levels above the next quietest—the Pontiac. Our test car was a well-equipped DL model with air conditioning and power steering. These features may have contributed to its relatively low fuel mileage compared with the other cars—31 mpg at 55 mph.

Its 86-cu.-in. engine is the smallest in this class. It works just fine in normal driving, but lugs considerably when the air conditioning is turned on. Without the air working, Alliance seems to have the best-balanced drive line of all the cars tested. Its engine, transmission, and chassis are well matched, so the automobile performs with uncanny ease, despite the displacement deficit. It's easy and comfortable to drive, and requires little attention to gear selection, even for slightly steep grades.

The instrument panel is bright, uncluttered, and has an efficient look with all the instruments located in a large housing directly in front of the driver. Also, the oil gauge tells you when you need an extra quart without having to look under the hood. However, the low center-console position of the radio and the complicated ignition switch are two items that bothered us. The radio is too low to reach easily from the driver's seat, and the ignition must be switched all the way off before restarting after a stall.

American Motors is banking on this car for its survival as an auto producer. Thanks to Renault, which developed the R9, on which Alliance is based, AMC has a highly competitive product. (For more on Alliance, see the 4,000-mile test in this issue.)

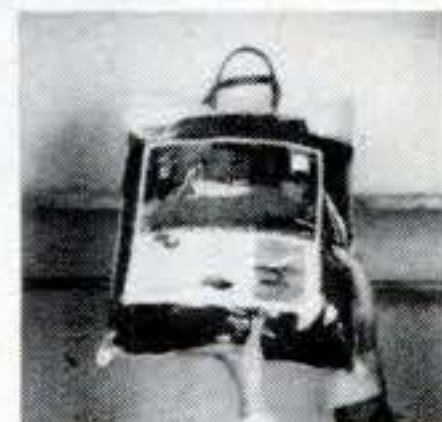
Chevrolet Chevette diesel

The Chevette diesel ranks near the top of the economy-car list, thanks to its Isuzu-made engine and five-speed transmission. In addition to achieving quicker acceleration, we found that the engine ran quieter and smoother than earlier models. Diesel-exhaust smell and smoke were not a problem,

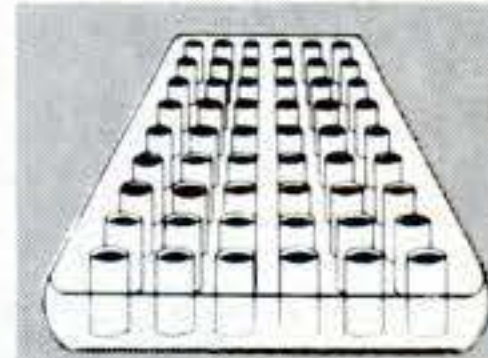
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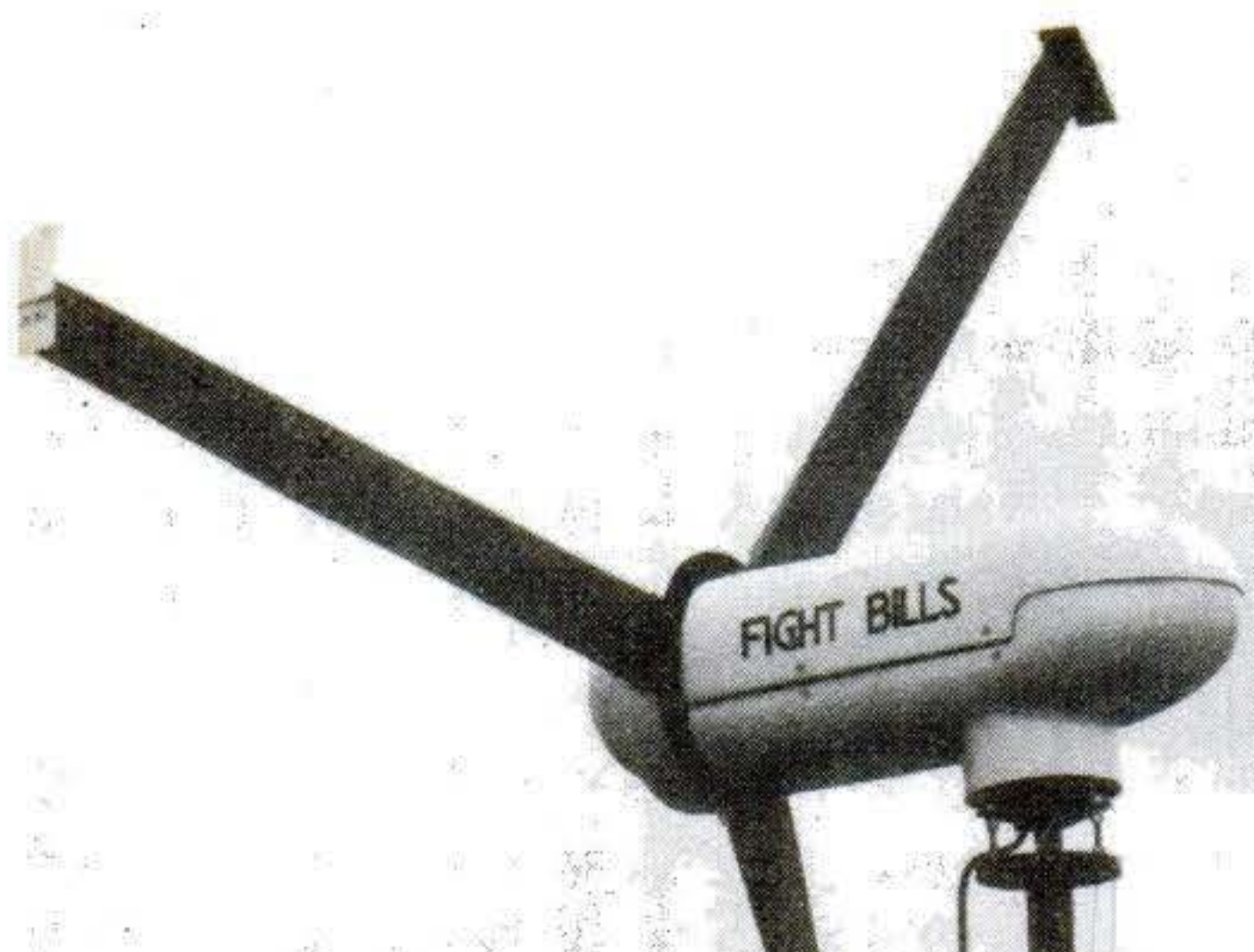
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PS car test & driving report

and the start-up delay in cold weather has been trimmed to less than 10 seconds. The gear throws are short and smooth, and gear engagement is quick and positive.

Chevette was the lone rear-drive car in this lineup, so the inherent interior space disadvantage of a rear-drive layout was especially apparent. The transmission tunnel is huge in com-

EPA fuel mileage (mpg)

	AMC Alliance	Chevy Chevette diesel	Ford Escort	Plymouth Turismo	Pontiac 2000	VW Rabbit diesel
Highway	48	59	47	50	52	56
City	34	42	33	32	31	43
Calif. city	35	42	29	32	28	43

PS fuel-mileage tests

(steady-state mpg)

35 mph	46	59	49	42	52	57
55 mph	31	40	35	33	35	36

parison with the small bulges in the front-drive competitors, and that cuts down on leg room and foot room for front and rear passengers.

But with a price tag of about \$7,700, Chevette is about the lowest-cost diesel you can find—priced lower, in fact, than many of its gasoline-powered competitors.

Ford Escort

Besides the car's light weight and small engine, the key to Escort's fuel economy is a transmission with tall gears. These allow the engine to run at low revs even at high road speeds. For example, if you decide to select second gear at five mph, you can remain in that long gear until 60 mph without over-revving the engine. However, because of the diminutive power output of the small-displacement four-cylinder, there's very little performance available until the engine is turning within its proper power-band range. That means at slower speeds, second gear is too high and first gear is too low. This setup is not as well balanced between economy and performance as the other cars in our test group and can be bothersome in city driving, where frequent gear changes are required.

Our Escort was bare-bones simple. There wasn't a single frill or complicated accessory in sight. We got the feeling that few things could go wrong, and if problems developed in the running gear, they would proba-

Continued

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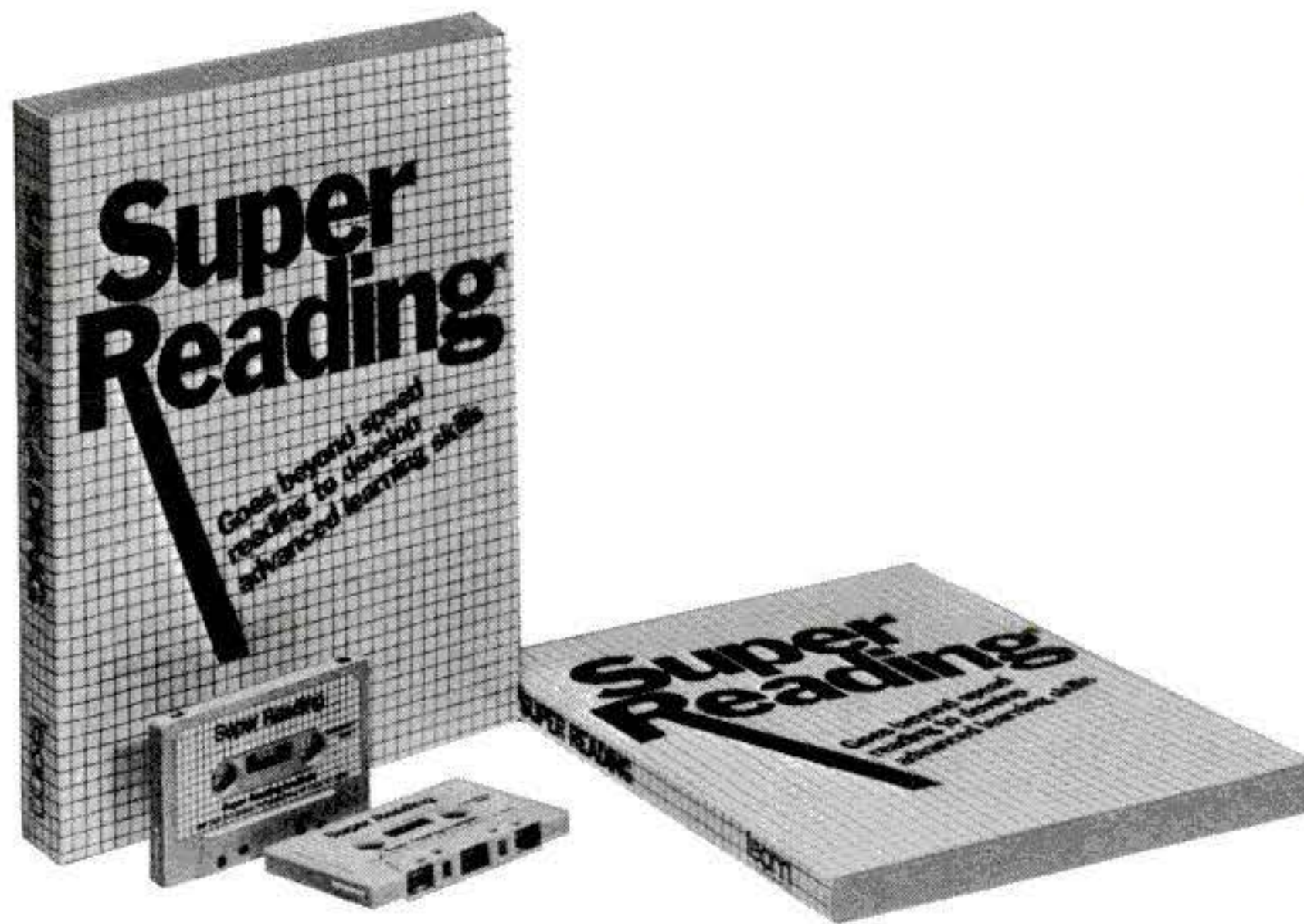
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GOOD NEWS

We went to one of America's leading publishers of self-study educational programs and the man who is regarded as one of today's foremost authorities on reading and learning. Our instructions were to create a program that would make it easy for everyone to learn to read faster, with greater understanding. The program he developed also had to be economical so that it would be within almost everyone's reach. After two years of development he finally achieved the goal . . . we call it THE SUPER READING SYSTEM.

WHAT, EXACTLY, IS SUPER READING?

First, the man who authored this home-study program is Russell Stauffer, Ph.D., Professor Emeritus at the University of Delaware. Dr. Stauffer has authored major textbooks and is considered to be one of the top researchers on how and why we learn. He is one of the few people admitted for membership in the Reading Hall of Fame. Second, the program is published by the same organization that publishes communication skills programs that are used by many of this country's leading businesses, government agencies and professional societies. In fact, many of the skills taught in THE SUPER READING SYSTEM are the very same as those taught in their reading programs that sell for three to four times the price of SUPER READING. Third, there are no gadgets or devices with SUPER READING. Authorities agree that these do not make you a better reader.

What you will get is a practical program that shows you a *new way to think*. Using a comprehensive instruction manual—over 280 pages—a teacher-on-cassette guiding and motivating you through every step of the program, you will discover a totally new way to read and learn . . . incredibly fast. *You will learn how to use your brain more efficiently.*

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WHO CAN BENEFIT FROM THE SUPER READING SYSTEM?

Executives, students, professional people, men, women, managers, technicians . . . anyone who reads for career or pleasure will benefit from SUPER READING. There's even a special edition for children ages 10-16. Just think of how much time you

now spend reading. Then consider what your life would be like if you could *read twice as efficiently.*

LISTEN AND LEARN AT YOUR OWN PACE

No matter how slow a reader you are now, THE SUPER READING SYSTEM is designed to get you started on this new way to read quickly and painlessly. In just a few days you'll begin to see an improvement. The teacher-on-cassette will be your guide through this remarkable program. You'll practice on materials you read everyday. *Your living room becomes your classroom.* You should complete the course in about 20-25 hours. But, you set the pace . . . you create your own schedule. Practice at home, the office . . . wherever or whenever it's convenient.

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We've said a lot of things in this advertisement that may be difficult to believe. So we want you to see SUPER READING for yourself. Examine it for 15 days. Listen to the teacher-on-cassette. Then decide. If you feel that SUPER READING will not benefit you, simply return it for a full, no questions asked, refund. You have nothing to lose.

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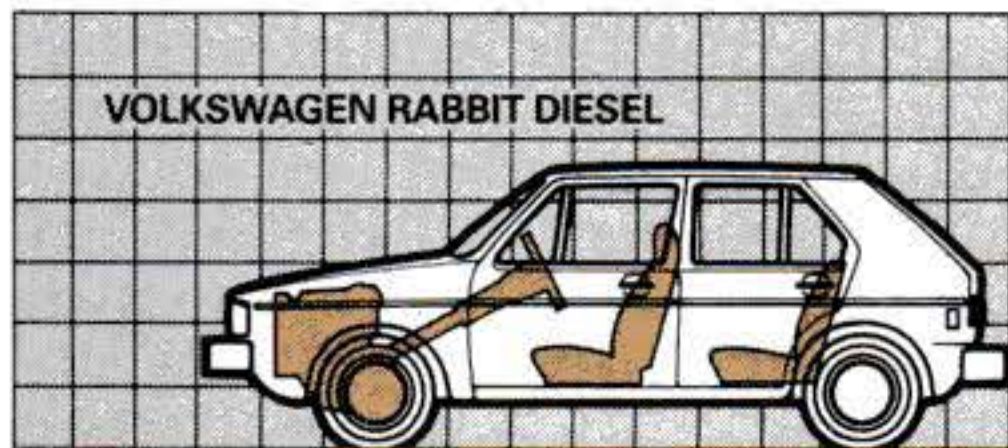
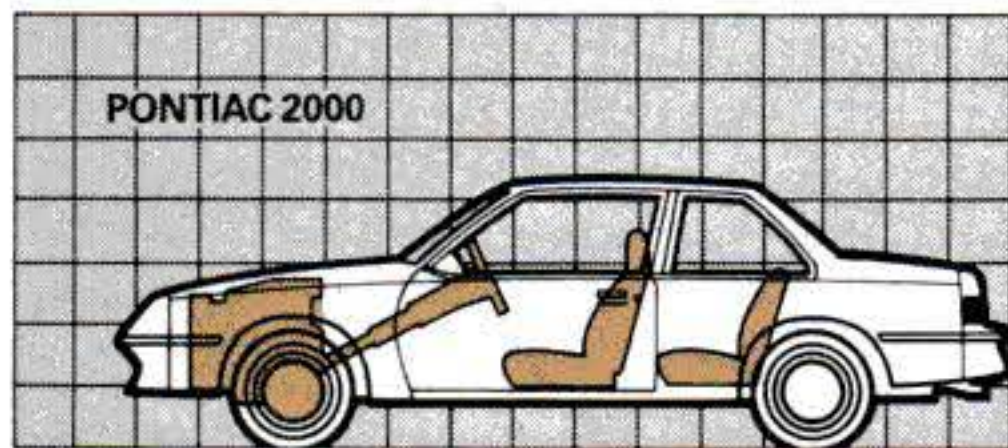
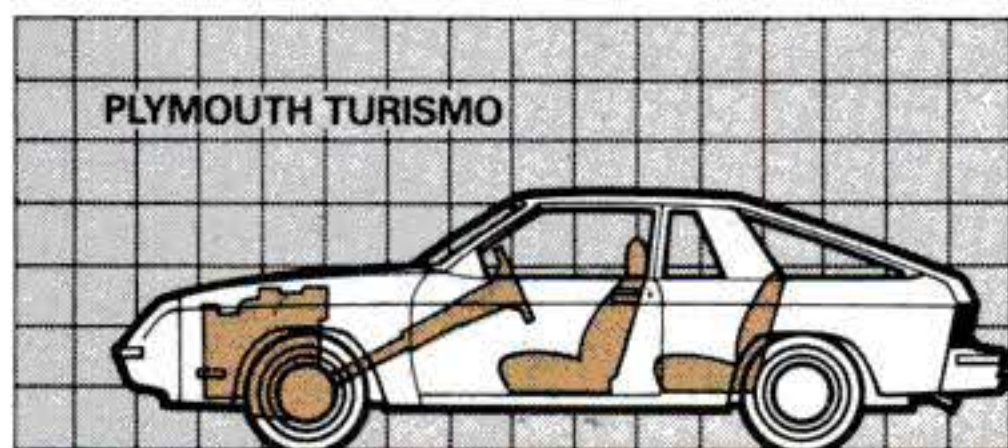
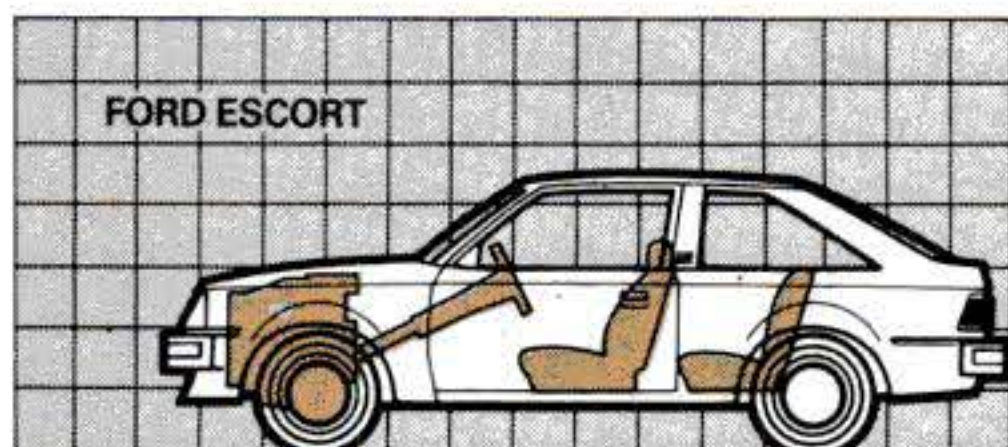
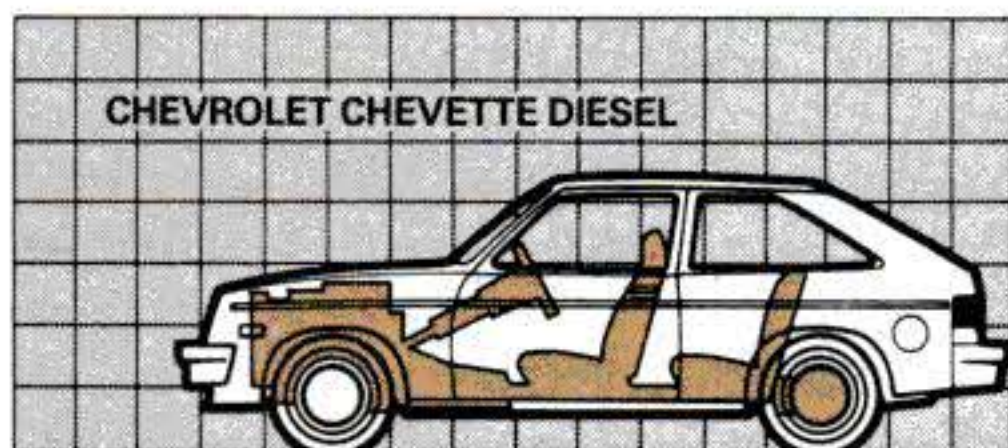
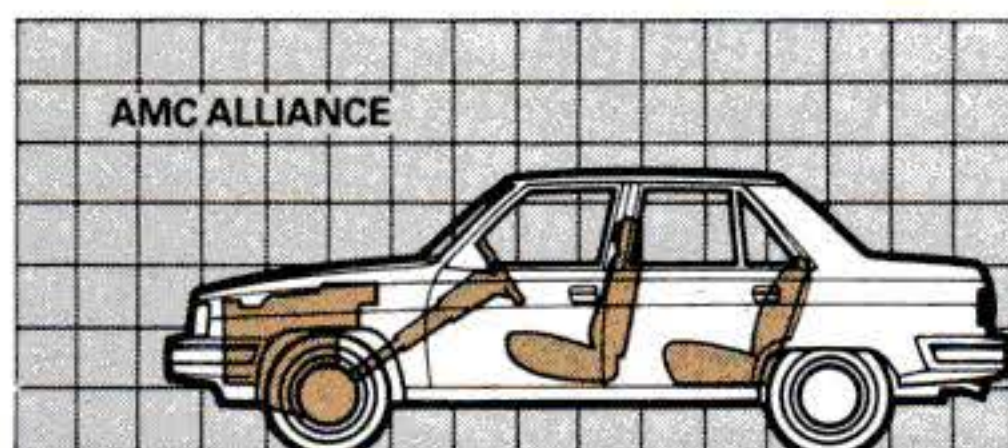
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bly be simple to repair. An adequate fresh-air ventilation system worked well in place of air conditioning, and the manual steering was surprisingly light and easy to handle. Escort proves that getting back to basics in transportation need not be unpleasant.

Plymouth Turismo

Turismo is the new name for the Plymouth TC3 Miser. The version we tested was equipped with the 1.7-liter (104.7 cu. in.) four that Chrysler buys in short-block form (block, crank, pis-

Continued



AMC Alliance, Chevrolet Chevette diesel, Ford Escort, Plymouth Turismo, Pontiac 2000, and VW Rabbit diesel—dimensions, specs, and test results

	AMC Alliance	Chevy Chevette diesel	Ford Escort	Plymouth Turismo	Pontiac 2000	VW Rabbit diesel
DIMENSIONS (inches)						
Wheelbase	97.2	94.3	94.2	96.6	101.2	94.5
Overall length	163.8	161.9	163.9	173.7	170.4	155.3
Overall height	54.5	52.9	53.1	50.8	52	55.5
Overall width	65	61.8	65.9	66.7	66	63.4
Track, F/R	55.2/52.8	51.2/51.2	54.7/56	56.1/55.6	55.4/55.2	54.7/53.1
Ground clearance	7	5.8	5	4.5	6.8	6.5
Front head room	37.1	38.1	38	37.2	37.7	36
Front hip room	53	49.9	52	52.6	49.1	46
Front leg room	41	41.6	41.5	42.5	42.1	40
Rear head room	37	37.3	37	34.4	36.5	35
Rear hip room	52.6	40.8	44.4	46.1	49.8	46
Rear leg room (min.)	37.1	30.9	35.8	28.7	31.2	36
Rear knee room (min.)	1.9	-2.4	1.1	-3.3	-0.8	1
Couple distance	29.1	26.7	29.6	26.3	28.1	31
SPECIFICATIONS						
Engine type	In-line 4	Diesel 4	In-line 4	In-line 4	In-line 4	Diesel 4
Displacement (cu. in./L)	86/1.4	111/1.8	98/1.6	104.7/1.7	112/1.8	97/1.6
Compression ratio	8.8:1	22:1	8.8:1	8.2:1	9.0:1	23:1
Carburetion	F.I.	F.I.	2 bbl.	2 bbl.	F.I.	F.I.
Net hp @ rpm	56 @ 4,200	51 @ 5,000	70 @ 4,600	63 @ 4,800	84 @ 5,200	52 @ 4,800
Net torque @ rpm	75.2 @ 3,000	72 @ 2,000	89 @ 3,000	83 @ 2,400	102 @ 2,800	72 @ 3,000
Transmission	5-speed manual	5-speed manual	4-speed manual	4-speed manual	5-speed manual	5-speed manual
Axle ratio	3.87:1	3.36:1	3.04:1	2.69:1	3.19:1	3.89:1
Tire make	Michelin	Uniroyal	Uniroyal	Firestone	Goodyear	Continental
Tire type	XZX radial	Fastrak radial	All Season steel-belted radial	Deluxe Champion radial	Viva II radial	TS 771 radial
Tire size	70R13	80R13	P165/80R13	P175/75R13	80R13	70SR13
Steering	Manual, rack and pinion	Power, rack and pinion	Manual, rack and pinion	Power, rack and pinion	Manual, rack and pinion	Rack and pinion
Overall steering ratio	21.8:1	18:1	21.3:1	18:1	22:1	20.8:1
Turns, lock to lock	3.2	3.4	3.52	2.88	4.04	3.3
Turn diameter (ft.)	33	30.2	35.1	36.4	34.7	30.8
Front suspension	Independent, MacPherson struts, coil springs	Independent, single lower arm, coil springs	Independent, MacPherson struts, coil springs	Independent, Iso-Struts, coil springs	Independent, MacPherson struts, coil springs	Independent, single lower control arm, coil springs
Rear suspension	Torsion bars with trailing arms	Solid axle, torque tube, coil springs	Independent with trailing arms, coil springs	Semi-independent trailing-arm type, coil springs	Trailing solid axle, coil springs	Solid axle, coil springs
Front stabilizer-bar diameter (in.)	0.87	0.87	0.87	1.0	0.87	0.87
Rear stabilizer-bar diameter (in.)	0.74	None	None	None	None	0.63
Trailing towing (max. lbs.)	Not recommended	Not recommended	1,000	1,000	1,000	Not recommended
Trailer tongue weight (max. lbs.)	Not recommended	Not recommended	100	100	100	Not recommended
Brakes	Power, disc/drum	Power, disc/drum	Power, disc/drum	Power, disc/drum	Power, disc/drum	Power, disc/drum
Brake swept area (sq. in.)	n.a.	279.77	203.5	202	251.72	n.a.
Fuel tank (gal.)	12.5	12.5	11.3	13	14	10.6
Trunk space (cu. ft.)	13	27	31*	34.3*	12.6	38.9*
Liftover height (in.)	32	29.6	31.2	27.6	32.7	29
Curb weight (lbs.)	1,979	2,300	2,016	2,201	2,353	1,920
F/R weight distribution (%)	60/40	54/46	62/38	62/38	65/35	64/36
Basic price	\$5,595	\$6,825	\$5,639	\$6,877	\$6,733	\$7,490
Price as tested	\$8,194	\$7,698	\$5,971	\$7,284	\$7,395	\$9,015
Major options (over \$100) on test car	A/C \$651, power steer \$196, AM/FM \$130	Destination charge \$290, rear defogger \$125, trim package \$150, custom seats \$130	None	2-tone paint \$133	Rear defogger \$125, power steering \$199, radio \$112	A/C \$650, power steering \$210, AM/FM cassette \$350, diesel \$525
TEST RESULTS						
Acceleration (sec.) 0-60 mph	18.9	23	15.6	15.4	15.1	23.8
Brake test (cool) 60-0 mph						
Stopping distance (ft.)	192	172	182	180	176	168
Pedal pressure (lbs.)	75	130	80	95	80	110
Brake test (hot) 60-0 mph						
Stopping distance (ft.)	176	165	173	186	148	157
Pedal pressure (lbs.)	130	100	110	95	115	130
Interior noise @ 60 mph (dBA)	68	76	73	72	69	73
Handling test (mph)	63.7	63.5	61.2	60	63.6	62.8
Maneuverability test (mph)	29.9	29.3	30.1	28	27.7	29.5
TEST CONDITIONS: Ambient temperature, 60°F; relative humidity, 85 percent; barometric pressure, 28.7 inches Hg						
*With rear seat folded						

PS serviceability ratings

The numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty; 4, easy; 5, very easy.

	Checking fluid levels Battery Master cylinder Windshield washer Engine oil Coolant	Checking the engine Spark plugs Distributor Carb adjustment Oil filter Oil fill	Replacing hoses Upper radiator hose Lower radiator hose Heater hoses	Changing bulbs Headlights Taillights Front running lights Front parking lights Front directional Rear directional Rear running lights	Checking fuses Spare-tire accessibility Changing belts
AMC Alliance	5 5 5 5 5	4 5 F.I. 4 4	5 3 3	5 2 3 3 4 2 3	4 4 3
Chevy Chevette diesel	5 4 5 5 5	- - F.I. 4 5	5 4 4	5 3 4 5 5 3 4	4 5 4
Ford Escort	5 4 5 5 5	5 5 - 3 5	5 5 3	4 5 2 2 2 5 5	5 5 4
Plymouth Turismo	5 4 5 5 5	5 4 5 5 5	5 5 5	5 1 5 5 5 1 1	5 5 4
Pontiac 2000	5 5 5 4 5	4 5 F.I. 4 5	5 5 4	5 4 5 5 3 4 4	5 5 5
VW Rabbit diesel	5 5 5 5 5	- - F.I. 5 4	5 4 4	5 5 5 5 5 5 4	5 5 4

Peppy four-cylinder engines in these light-weights make fuel economy fun. Note that Chevette is one of the few remaining sub-compacts that still uses rear drive.

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PS car test & driving report

Performance comparison with selected 1982 models

	Mpg (city driving)	Acceleration 0-60 mph (sec.)	Brakes 60-0 mph (hot) (ft.)	Handling (mph)	Maneuverability (mph)	Noise @ 60 mph (dBA)
Chevrolet Chevette diesel 4	40	27.5	176	58.6	27.6+	76
Ford Escort 4	31	16.6	181	60.5	27.6+	74
Honda Civic 4	41	16.6	171	59	27.6+	75
Plymouth TC3 Miser 4	36	15.5	210	58.4	27.6+	73
Toyota Starlet 4	38	22	198	59.8	27.6+	74
VW Rabbit diesel 4	43	27.3	163	58.3	27.6+	73

tons, and head) from VW. Soon this engine will be replaced by an equally economical 1.6-liter short block from Peugeot. The engine is smooth running and relatively quiet, and it puts out good performance for a car of this size and weight.

Inside, the first-time driver will notice a sparse-looking instrument cluster housing three tiny circular dials. We considered the dash appearance dated and gauges hard to read.

You pay a penalty for the slick appearance of the fastback roof line in this two-door model. Rear-seat room is less than acceptable for average-size adults: You'll find yourself pressing your head against the headliner while you ride—and knee room is almost as bad. Altogether, passenger space ranks a level below the competition. (Note: Our rating chart is distorted by the extra hip room in the wide-body Turismo, where it's graded as equal to the other small cars.)

A push button on the right side of the rear seat frees the seat back to swing forward and open up more than 30 cubic feet of storage space, an important advantage of each of the test cars except the Alliance and Pontiac 2000 notchback.

Pontiac 2000

The 1.8-liter (112 cu. in.) label on the 1983 four-cylinder remains the same, but the engine is completely different from last year's. We found the made-in-Brazil fuel-injection engine a better and smoother performer. It makes the 2000 the quickest of the test cars and about 2.5 seconds faster than a similar car tested last year. The added performance does cause some unfavorable reaction in the behavior of the car, however. During hard acceleration a seesaw effect can be felt as each front wheel pulls independently. On wet pavement the loss of traction from that strange behavior could be critical.

While the 2000 economy model is stripped of most convenience accessories, it still sports a tachometer. It's an

appropriate addition, since the eager engine runs to 6,500 rpm easily and smoothly. We noted that at 55 mph the rev counter clocked a fuel-saving 2,000 rpm.

Volkswagen Rabbit diesel

No, this is not the grand champion of fuel economy, the one that shuts off when you stop then starts itself when you press on the accelerator. That model was not ready at test time, so we substituted the regular diesel with five-speed, which is rated at a "mere" 43 mpg in city driving by the EPA. Essentially, this is the same car we tested a year ago, but acceleration is improved to a point where it can be described as adequate instead of awful. It's now 23.8 seconds from zero to 60 mph instead of 27.3. At highway speeds the diesel hums along easily and, with frequent downshifts, keeps up with normal traffic.

While the nine-year-old Rabbit body is well into middle age, its five-door layout is still one of the most practical in the industry. The rear seat, for instance, rolls forward in two movements to open up a storage compartment that rivals some big station wagons in capacity.

Finally, VW diesel manners are improving. Engine "rap" is noticeable at cold-engine start-up and when racing the engine at slow speeds, but on the highway it's difficult to tell whether you're driving gasoline or diesel.

Our choices:

Two stand out in my judgment, Escort and Alliance, but my award goes to Alliance even though it is a first-year car. It looks fresher inside and out, especially when compared with the older competition.—J. D.

I agree with Jim on the two stand-outs, but I have to reverse the order. Alliance was a refreshing and fun-to-drive car with one of the sweetest manual transmissions I've stirred this year, but I was most impressed with the well-made Escort's honest look and mechanical simplicity.—J. K.

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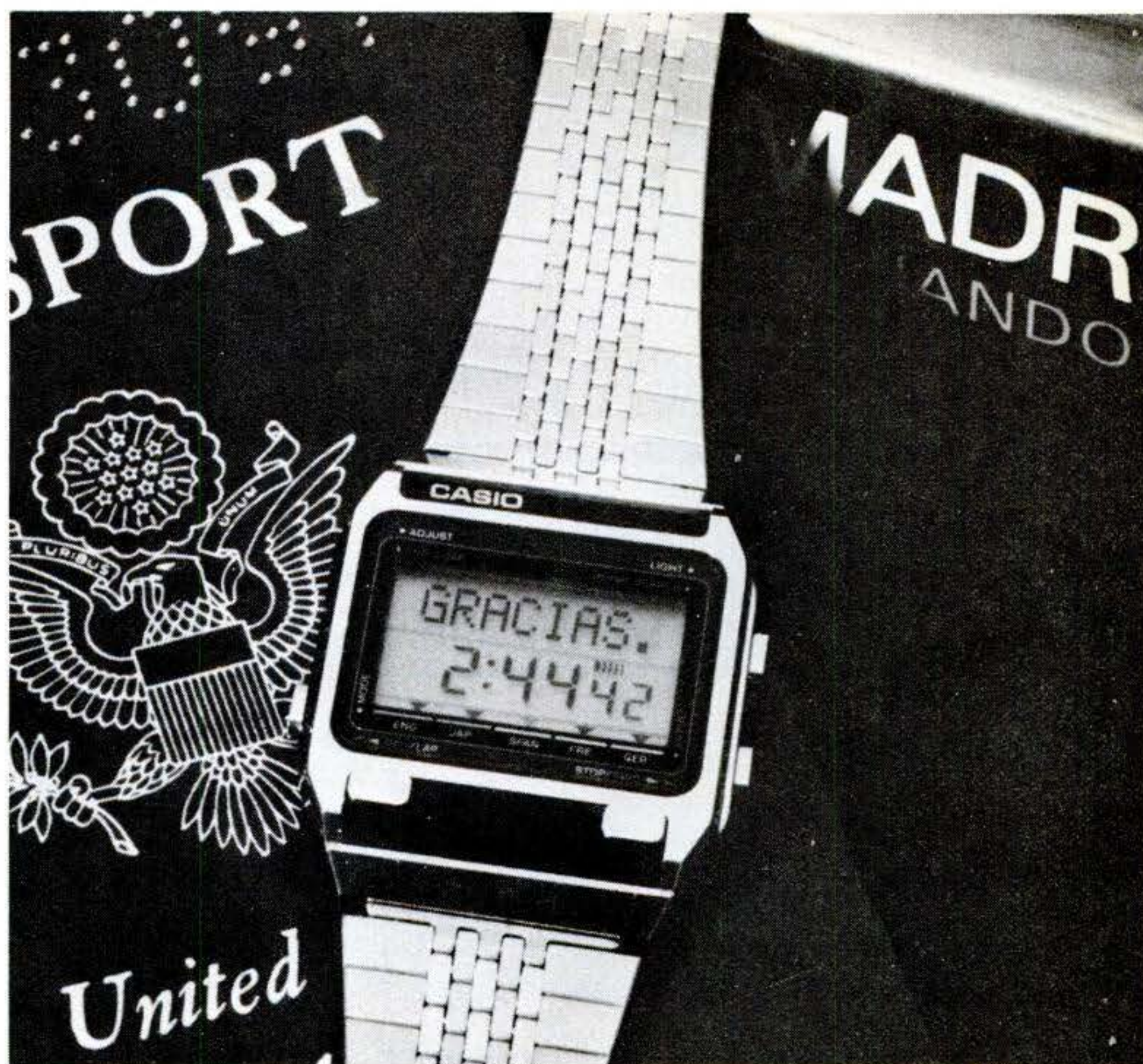
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ENG+SPA
10:58:37

Dictionary

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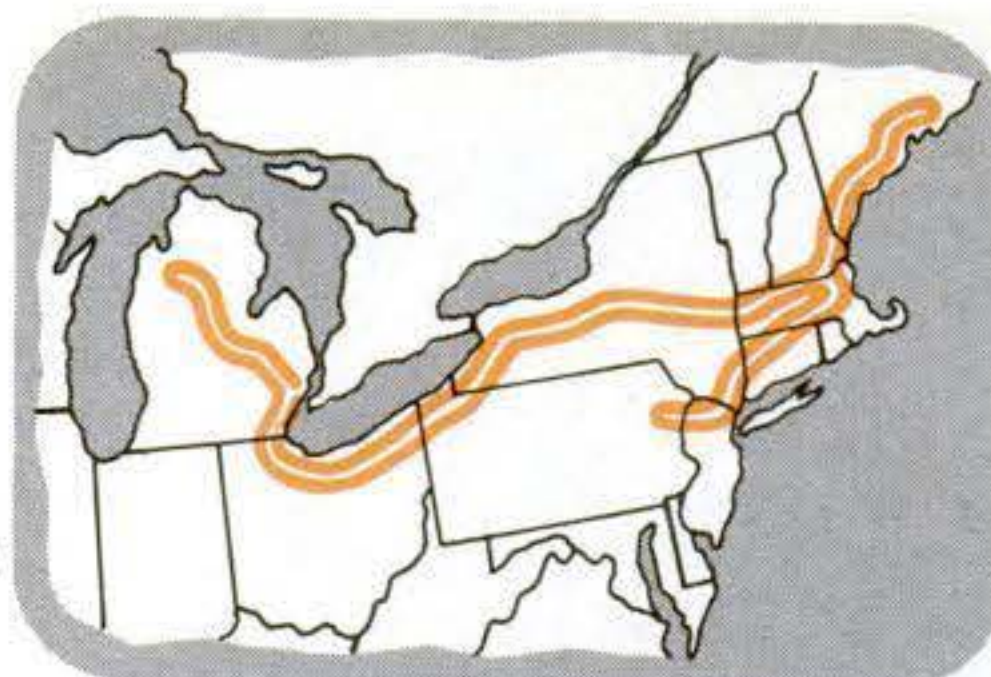
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PS 4,000-MILE TEST

RENAULT ALLIANCE



AMC's French hybrid is smooth, quiet, and a thrifty fuel sipper

By JIM DUNNE

Renault will find its reputation dramatically brightened when word of the AMC Alliance gets around. After driving the new hybrid for more than 4,000 miles (see map) under a wide range of road conditions, my opinion of the French marque has made a complete turnaround. American Motors' version of the French Renault 9 sedan greatly exceeded the expectations of this American driver.

In my test car the smallish 1.4-liter (86 cu. in.), four-cylinder engine was well matched to the silky five-speed manual transmission. Passengers told me the ride was as smooth as that of a big car. Appointments, including instrument placement and controls, are comfortably conventional and located in predictable places, a big change from previous seemingly eccentric Renault designs. Fuel economy was simply outstanding. Up close, here's what I found:

Engine. A throttle-body fuel-injection system makes certain the OHV 4 fires up quickly in cold weather, and keeps it running smoothly. There is occasional engine speeding at idle, but this quickly subsides as warm-up proceeds. Engine noise is relatively low, not the distraction it is in other Renaults. Best of all, when the air

conditioning is used, the engine does not change idle speed to any discernible degree. However, the power lost to the compressor is noticeable when you accelerate. In 4,500 miles of driving a fairly green engine mostly at high speed, I used less than one quart of oil.

Transmission. The five-speed shifts smoothly, and the lever offers the short, sure throws that make stick-shifting fun. Most important, the gear ratios are well matched to the power curve of the engine. This is important since there are only 75 ft.-lbs. of torque available. Each ratio delivers power to the drive wheels with no soft spot and no short range where the engine overrevs. Gear noise is virtually nonexistent.

Ride and handling. Overall, I was impressed by the tightly suspended chassis that rides without the usual excessive lean and bounce. At high speed the ride is level and shake-free. On smooth city streets, you can't ask for a better small-car ride. But on extremely rough surfaces the ride does deteriorate. Then, you feel the bumps individually and clearly hear the tires and suspension working.

Handling leaves little to be desired at normal driving speeds. The steering response is about the best you will find on a passenger car—quick, sure, and without the insulation of a power boost. On freeways, the front-biased weight of front-drive does its job. The car easily tracks in a straight line. Also, Alliance seemed highly resistant to side winds.

Interior. Alliance fits the driver like a custom-made suit of clothes—comfortable and tailored to fit snugly without restricting movement. However, while AMC may claim five-passenger accommodation, Alliance is strictly a four-passenger sedan. Probably the biggest surprise is the Americanization of the instrument panel, a rewarding departure from earlier Renault designs. Controls are set in conventional positions—mostly on stalks on the steering column—and easily readable gauges are grouped in front of the driver. One flaw in the layout is the position of the radio. It is out of reach, down near the floor and partially hidden by the gearshift lever. Perhaps more annoying is the ignition lock, which is recessed in the steering column at the side where it can't be seen unless the driver leans over.

French automobiles are known for seating comfort, and the Alliance carries on that tradition. The front seats are among the most comfortable in the subcompact class. The six-way seat adjustment makes finding a just-right position a cinch. The pedestal support on the floor really does open up more foot room for rear-seat passengers, and that's important in a car with Alliance's limited rear-seat space.

Fuel economy. The EPA numbers are impressive. With 34 mpg in the city and 48 for the highway cycle, Alliance will be one of the most fuel-efficient U.S.-produced autos this year. However, buyers should keep in mind that these numbers should only be used for comparison. (To see how Alliance stacks up against other U.S. economy cars, see this month's car test.) For me, Alliance delivered an honest 44 mpg average on mostly freeway trips. It's the best I've ever experienced in everyday driving. Turn on the air conditioner, and the average drops to 41 mpg, still 10 mpg above the competition in real-world conditions. In mixed city-and-highway driving I got 39.3 mpg, a personal best. This high mileage isn't surprising since Alliance is a 2,000-pound-class lightweight, the engine is one of the smallest available, and the four-door has a slick C_d of 0.39.

The new Alliance is a miracle for AMC. Not only does the car show a general excellence in construction and appointments, it's also a state-of-the-art front-drive that AMC could not have produced on its own. Combine those three elements and you have tough competition for Escort, Chevette, Horizon, and the imports, and a product that comes close to being the best in its class. **PS**

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PONTIAC  **WE BUILD EXCITEMENT**

PS | What's News

There is something appealing about the idea of a windmill making free, nonpolluting kilowatts from the breeze. So it's not surprising that the subject of windmills has been attractive to POPULAR SCIENCE readers for many years.

Most of the interest has centered around individual windmills—ones a homeowner could buy, erect on his roof or in his back yard, and hook into his home electrical system. We have talked about the huge industrial machines under development, of course. But those were always advanced research and seemed to have little hope of becoming producers of practical power any time soon.

Now the picture is changing rapidly. In recent months, huge fields of windmills have begun springing up in the California hills. They will produce important amounts of electricity—enough to power whole communities and towns. We have talked about many forms of renewable energy in PS over the years—wind, solar, ocean-thermal gradient, biomass. But now it seems that wind may be the first technology (other than hydropower) to cross that vast barrier between an interesting research project and a practical, economical energy source. Today, perhaps 200 windmills are producing commercial electricity in several wind farms. But that's just the beginning. Many more are under construction, and they will be pumping millions of kilowatt-hours of electricity into the California grid within the next few years. It's a fascinating trend, and the article containing the details starts on page 58.

Plastic cars

The amount of plastics used in cars, primarily to reduce weight and improve gas mileage, is not growing as fast as once predicted. A few years ago, some analysts said we'd be using 500 pounds of plastics—mostly composites—per car by the mid-1980's. Now it seems that level won't be reached until the turn of the century.

The slow growth rate is attributable to stable gas prices and high interest rates. Most of us have apparently grown used to the idea of paying well above a dollar a gallon for gas. In addition, we have become more interested in the selling price of a new car than in its gas mileage. And plastics, though lighter, are usually more expensive than the steel they replace. So

auto makers have been inclined to go the cheaper rather than the lighter way. Industry observers say the use of plastics in cars will continue to grow, but the rate will be somewhat slower than that envisioned in the dark days of the gas shortage.

Fusion—not too fast

We've all been encouraged by the reports from Princeton and Lawrence Livermore [PS, May '82] that break-even fusion is now on the horizon. Break-even, of course, is the proof of scientific feasibility. Once we achieve it, we'll know that a fusion reactor capable of producing more energy than it takes to run can be built. And it will mean that the hope of harnessing the energy of the stars in a controlled way for the production of electricity has been finally realized.

But in a surprising new development, the Department of Energy's new Magnetic Fusion Advisory Committee has said that maybe we're rushing things and pushing too hard for break-even. The DOE has committed itself to the investment of \$400–\$500 million a year in the fusion program. The two so-called "mainstream" projects are the Princeton Tokamak Fusion Test Reactor and the Lawrence Livermore Mirror Fusion Test Facility. The problem is that these machines are both very expensive and will between them gobble up most of the money set aside for the next few years. That means there won't be much left over for other research that may also be worthwhile. These two projects may well demonstrate break-even. But according to the committee, they may not turn out to be practical machines that utilities are interested in building. Perhaps some of the other fusion concepts being worked on at other laboratories would hold better promise. And, say these critics of the present program, it doesn't make sense to put all of our eggs in the Princeton and Livermore baskets—if that means choking off all other approaches. To put it another way, we might do a better job if we didn't throw everything into the race to produce break-even but undertook instead a broader and more balanced approach.

The outcome is, of course, unclear at this time. But fusion researchers point to a disturbing parallel. During the development of fission reactors, a number of al-

ternative schemes (high-temperature-gas reactors [PS, Feb. '75]; thorium slow breeders [PS, April '78]) were abandoned and all chips put on the light-water development program. It worked, and we now have a lot of light-water nuclear plants in operation. But, say the critics, was that the best way to go? Today, the nuclear industry is in trouble, and utilities are canceling orders for new plants. If instead of rushing ahead with light-water development in the early days of nuclear power we had worked on a broader variety of concepts, would we have developed a reactor that would have been cheaper, more efficient, or inherently safer? It's a question nobody can answer with certainty. But it is on the minds of those charged with charting our future course in the development of fusion power. They fear that by sacrificing everything to achieve break-even as quickly as possible we may miss some important options that could spell the difference between success and failure in the future.

The artificial prospector

Can a computer learn to think, reason, and analyze like a human expert? In a recent article on so-called expert systems [PS, Sept. '82], we reported on a number of attempts by artificial-intelligence researchers to design computer programs that could make medical diagnoses, analyze geological-survey maps to find unknown ore deposits, and perform other analytical chores.

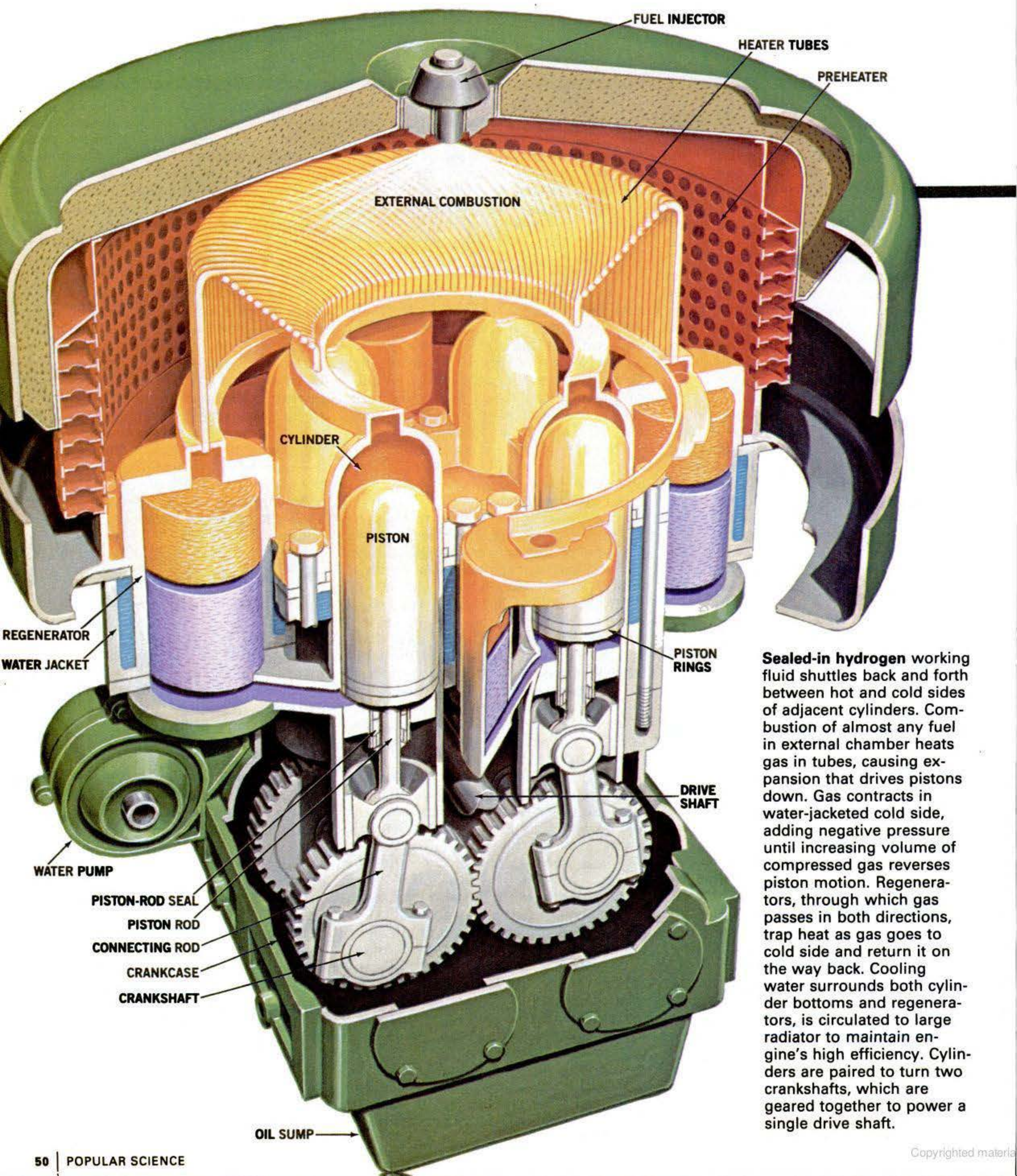
Now, researchers from SRI International and Fairchild Laboratories in Palo Alto, Calif., report in the journal *Science* that a program called PROSPECTOR has found a previously unidentified ore-grade deposit of molybdenum. The deposit was found by the program in its analysis of geological maps of parts of Washington state. "This appears," says the team, "to be the first reported determination of the location of mineralization by such a computer-based approach."



Editor-in-Chief

Stirling auto engine

—a lot of progress, but...



Sealed-in hydrogen working fluid shuttles back and forth between hot and cold sides of adjacent cylinders. Combustion of almost any fuel in external chamber heats gas in tubes, causing expansion that drives pistons down. Gas contracts in water-jacketed cold side, adding negative pressure until increasing volume of compressed gas reverses piston motion. Regenerators, through which gas passes in both directions, trap heat as gas goes to cold side and return it on the way back. Cooling water surrounds both cylinder bottoms and regenerators, is circulated to large radiator to maintain engine's high efficiency. Cylinders are paired to turn two crankshafts, which are geared together to power a single drive shaft.

The promising power plant may finally be ready to roll—if joint DOE-NASA funding continues

By E. F. LINDSLEY

ILLUSTRATION BY RAY PIOCH

Frankly, if they'd left the driving to me, I'd have waited for the car coming from our left to clear before pulling out of the driveway and onto the road. The timing and distance were just a bit tight. Besides, the engine under the hood of our car didn't even sound as if it were running.

But my driver, Jeff Spraker, a technician at the laboratory where the car's unusual engine is being developed, kicked down hard on the gas. I heard gravel spin out from under our tires as we shot out of the driveway and across the road with a smoothly fluid sweep. Oddly enough, I still didn't hear much from the engine—no exhaust roar, vibration, or other symptoms of a floorboarded takeoff.

That was because the car we were riding in was powered by the latest experimental version of a Stirling engine, a power plant whose pistons are driven by externally heated hydrogen gas instead of fuel-air firings inside its cylinders. I was visiting Mechanical Technology, Inc., in Latham, N.Y., to see how the NASA-managed development program was proceeding, and particularly to find out if this latest Stirling program could overcome the vexing engineering problems that have frustrated past efforts to fulfill the Stirling's promise of high fuel efficiency, low emissions, and multi-fuel

capability. What I found, as the test drive suggests, was highly encouraging. But that's getting ahead of the story.

To understand where the Stirling engine is now and where it's been requires some backtracking. The engine was invented by Robert Stirling, a Scottish minister, back in 1816, long before the Otto and diesel engines we think of as conventional. Conceived as an alternative to steam engines, whose high-pressure boilers could be dangerously explosive, the Stirling transferred the heat produced in an external combustor through a heat exchanger to a working gas that drove reciprocating pistons. Stirling also originated the idea of employing a regenerator to bank thermal energy when it wasn't needed, returning it when it was. With regeneration, the Stirling cycle promised the highest efficiency theoretically possible in a heat engine, as the laws of thermodynamics—not yet developed in Stirling's day—would show. And external combustion carried another advantage over other engines: Stirlings could run on any fuel—from wood chips to cow chips.

Many of them did just that. Until about 1920, small wood- and coal-powered Stirling engines saw wide use pumping water and generating electricity on farms and in remote communities. They were even sold by Sears, Roebuck. But these early designs used air as the working fluid. Steam, with the technology then available, was more efficient.

America's hole card?

Nevertheless, in 1938, N.V. Philips of the Netherlands initiated modern research on the Stirling. Since that time, a great many development programs have sought to take advantage of the Stirling's inherent efficiency advantage to generate electricity, operate refrigeration units, or power automobiles. Both General Motors and Ford pursued Stirling programs in recent years, but eventually abandoned them in the face of serious engineering and financial obstacles.

Despite this, in a 1975 study of advanced automotive engines performed for the Department of Energy, NASA's Jet Propulsion Laboratory named the Stirling along with another design—the Brayton-cycle, or gas-turbine, engine—as the most attractive candidates for future automotive power plants. Then, in the post-fuel-shortage flurry of 1978, the two agencies jointly set up a program to develop and, by 1984, demonstrate in a car a practical Stirling automotive engine. It was to be a three-step pro-

gram, using as a baseline the P-40 research engine already being developed by a Swedish contractor, United Stirling, Inc. This was to be followed by a Mod I engine with greater power and less weight than the P-40. Finally, when the Mod I had yielded its secrets, a Mod II engine would be built and demonstrated in a car. The hope was to have the Stirling ready to serve as America's ace in the hole if a really prolonged and serious fuel shortage occurred.

The contract for the Mod I engine went to Mechanical Technology, Inc. The company's goals, as MTI vice-president Gene Mannella explained to me, are to achieve a 30 percent fuel-economy advantage over equivalent spark-ignition engines, low exhaust emissions, and ability to use a variety of fuels with easy changeover.

"And all of these objectives must be coupled," assistant project manager Bill Ernst added, "with normal automotive reliability, durability, competitive manufacturing and operating costs, and acceptable noise and safety levels."

These are bold goals, as I knew from my past experience with Stirlings, including having seen William Beale's Stirling-cycle air conditioner [PS, Aug. '74] and electric generator [PS, June '78] and even having built a little model Stirling from ancient PS plans [PS, July '65]. These and other engines I've seen have run all right, but they didn't shake my impression of the Stirling as an elegant, exotic engineering novelty beset with too many mechanical and thermal problems for everyday automotive use.

Thus, I went to MTI in a skeptical frame of mind. Specifically, I wanted to know:

- What kind of mechanical arrangement would be used to translate the engine's hard-to-define operating cycle—lacking both valves and a timed ignition event—into output power?

- How would the engine overcome the necessary thermal time lag between putting heat into the combustor and getting action out of the pistons?

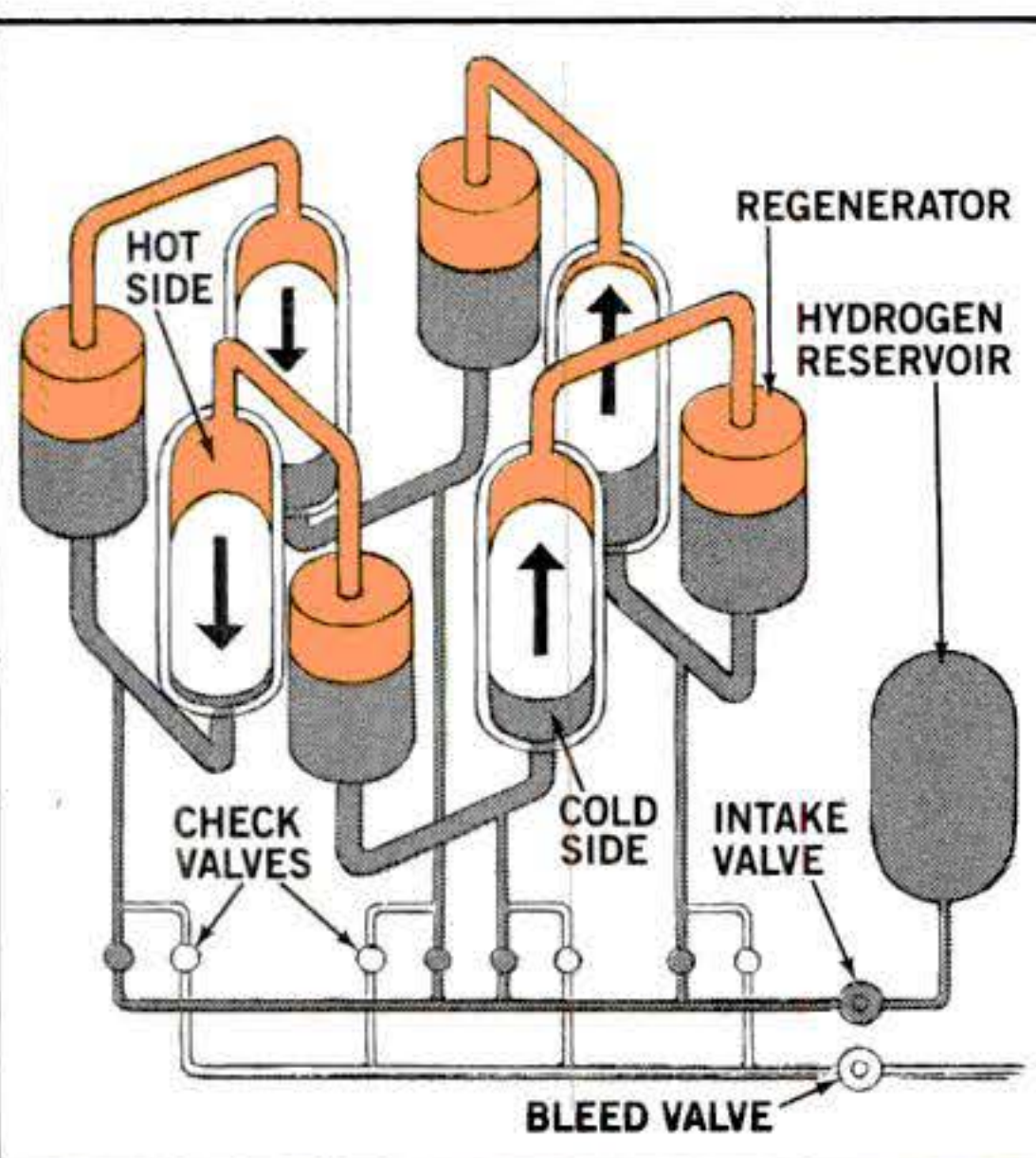
- Could warm-up times in cold weather be kept acceptably short?

- Could effective seals be designed to keep the pressurized hydrogen gas contained within the cylinders?

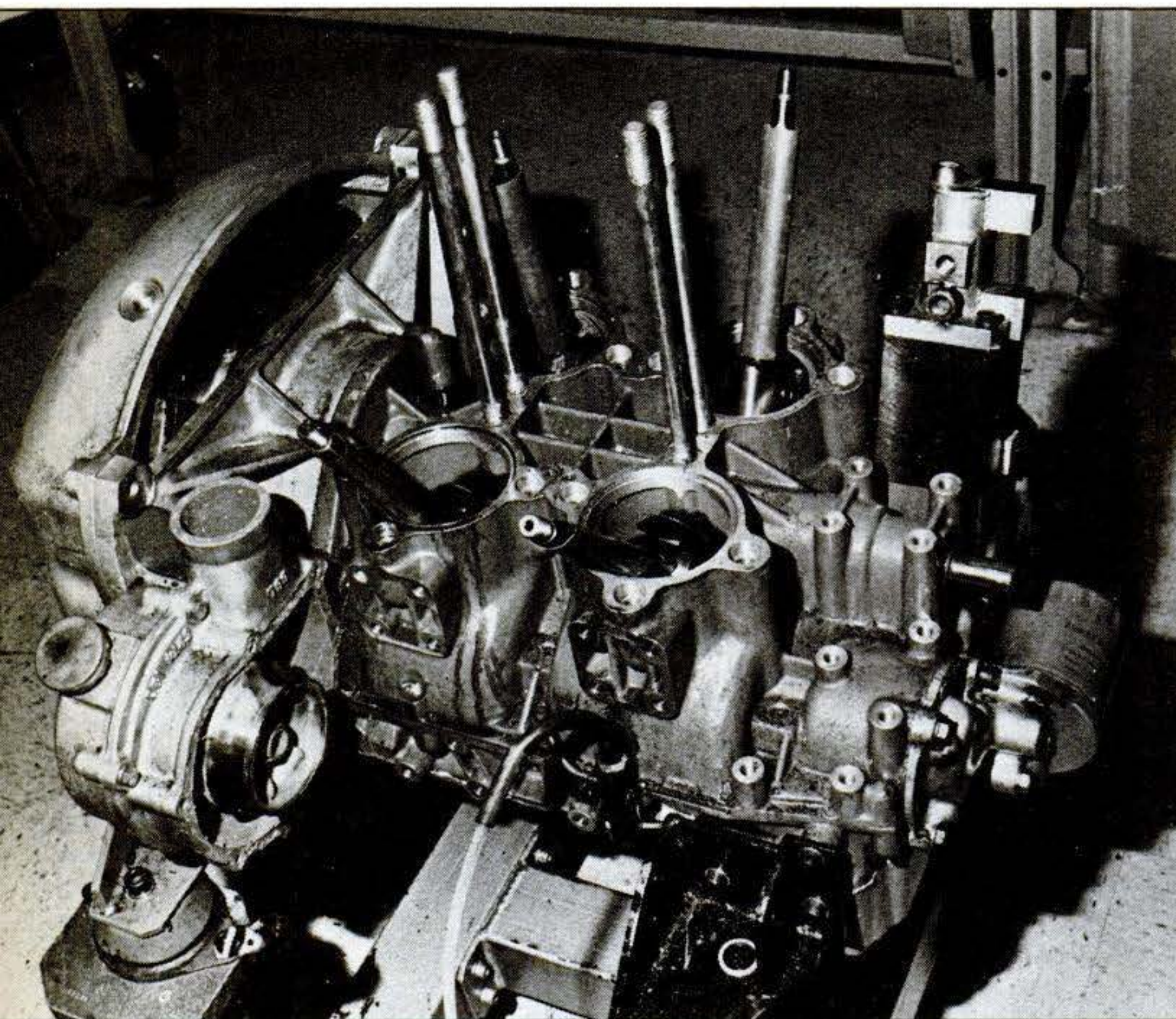
- Finally, could such an engine perform in a normal car—in ordinary traffic—without a team of technicians aboard to keep it running?

That last question would be answered in due course; first Dr. Mannella showed me around the lab. As

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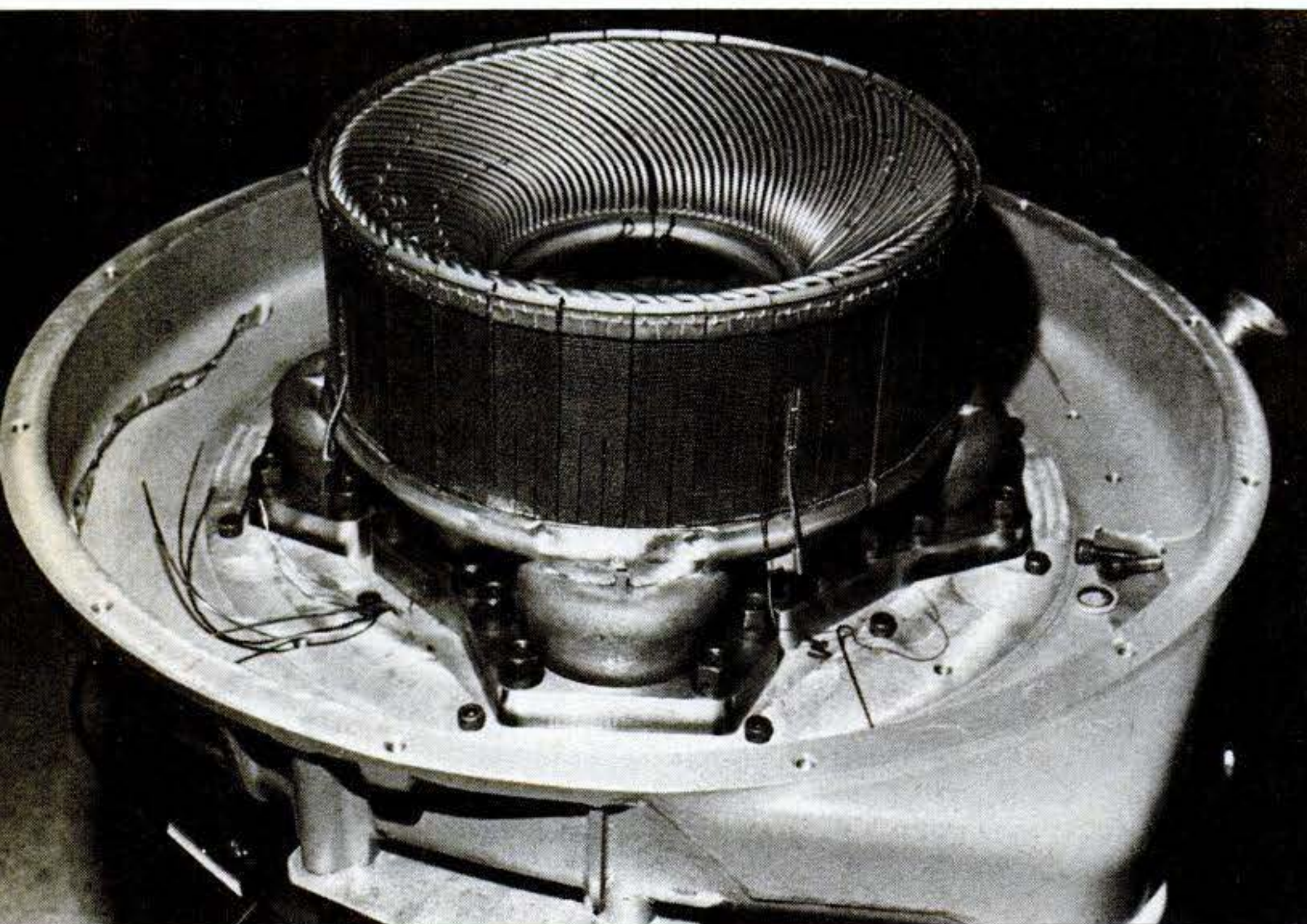


Volume of gas in cylinders is varied under microprocessor control to allow fast engine response. Gas from tank is valved to cylinders to increase power.



Besides its two crankshafts, engine's crankcase is conventional. Highly pol-

ished connecting rods are sleeved to prevent damage to critical seal areas.



Stirling's external combustor contains a central nest of hydrogen-filled heater

tubes. Combustion is continuous but modulated to match car's varying loads.

he explained the details of the engine, Mannella impressed me as a sleeves-up type of engineer who easily translates difficult engineering concepts into things that run. Both he and his assistant, Bill Ernst, seemed solidly sure of their development work.

My misgivings about the complex mechanical linkages employed in some earlier Stirling engines were

quickly put to rest when Mannella showed me one of the Mod I engines disassembled. Here was an ordinary-looking crankcase with a V4 setup. It did have two crankshafts geared together to drive a single output shaft, but it certainly appeared simpler and more conventional than the oddball rhombic drives and swash plates I'd seen on other Stirlings.

"It's a kinematic, double-acting engine," Mannella told me. Kinematic means that the pistons are mechanically linked to the crankshafts. Double-acting means that the two working chambers, hot and cold, are separated by a single piston and the hydrogen working fluid operates against both upper and lower faces of the pistons. "With this approach," Ernst said, "we can have an absolutely vibration-free, perfectly balanced engine."

Thermal lag

Nice, but those complex drive linkages were meant to overcome the Stirling's inherent problem of matching engine output to driving demands. Simply using the throttle to increase or reduce fuel does not yield the split-second changes you get from a carburetor or injection pump delivering fuel directly into the cylinders. With external combustion, there is a time lag before the effect of a fuel-quantity change in the combustion chamber is translated into gas-pressure change in the separate cylinders.

Some other Stirlings have used swash plates, which actually alter the mechanical length of the working strokes, and thus the working volume, to produce quick response to the driver's demands. Owners of lawn tractors with hydrostatic drive, which also use swash plates, will understand this. It may still be the best way to control the Stirling.

MTI's engine, though, with its simpler, unchanging crank throws, manages power output by altering the volume of the hydrogen working fluid in the engine. A microprocessor monitors fuel input and adjusts hydrogen pressure to match it by valving gas to and from a storage reservoir. "At idle, the pressure is 450 psi. At maximum power, it's 2,500," Ernst told me. In a sense, that's not much different from a throttle plate in a carburetor, which controls the pressure of air, the working fluid in an internal-combustion engine.

That sounds simple enough, but it makes even more crucial a difficult problem that has plagued Stirling development: sealing in the hydrogen.

In a way, the Stirling is an engine divided against itself. The power-producing side contains hydrogen under pressure, and the lower side has a crankshaft that must be bathed in oil. Hydrogen is one of nature's most difficult gases to seal, but somehow the seals must allow the connecting rods to bridge this boundary region of high-pressure hydrogen on one side and engine oil on the other. At the moment, MTI is having fairly good

luck with a double seal, one part that keeps the hydrogen in and another that scrapes the oil from the reciprocating connecting rods.

But if no oil is permitted inside the cylinders, how are the piston rings lubricated? "They're PTFE materials," Ernst said, using the chemical designation for the slippery material commonly called Teflon. "They run with no lube. A film builds up on the cylinder walls, and the rings don't wear. We've operated them for thousands of hours with no wear," he said.

If that problem is close to solution, what about two other difficulties caused by hydrogen's unique properties? The gas can also leak by diffusion, actually penetrating the metal structure by sneaking between the molecules. An apparent solution to this problem was stumbled upon when some impure gas found its way into MTI's lab. "When the hydrogen is doped with carbon monoxide or carbon dioxide, an oxide coating builds up on the walls of the working-gas chambers and passages," Ernst ex-

“I’m switching from unleaded gas to diesel fuel to gasohol as we go. This engine doesn’t care what it runs on”

plained. Apparently, these thin coatings are a more effective hydrogen barrier than the metal alone.

Hydrogen's other ability may prove a more serious problem. When metal parts working at elevated temperatures are exposed to hydrogen, they tend to become brittle and lose strength. To date, MTI has used exotic metals to resist the gas's destructive bite. But such metals are strategically critical and extremely costly. The next step is to find less-exotic materials.

Multi-fuel appetite

Meanwhile, the Mod I engine is running up to all expectations—and not just on test stands. In answer to my last question, Mannella and Ernst turned me over to technician Jeff Spraker for a test drive. Both emphasized that the car is not intended as a demonstration car, but as an engineering test vehicle.

As Spraker slid into the driver's seat, I asked him how long it took to get the car going, aware that external combustion can mean long start-up times. "On a warm day like today,



Teakettle-topped combustor housing dominates view of Mod 1 Stirling engine,

shown installed in test AMC Spirit by MTI's Bill Ernst (left) and Gene Mannella.

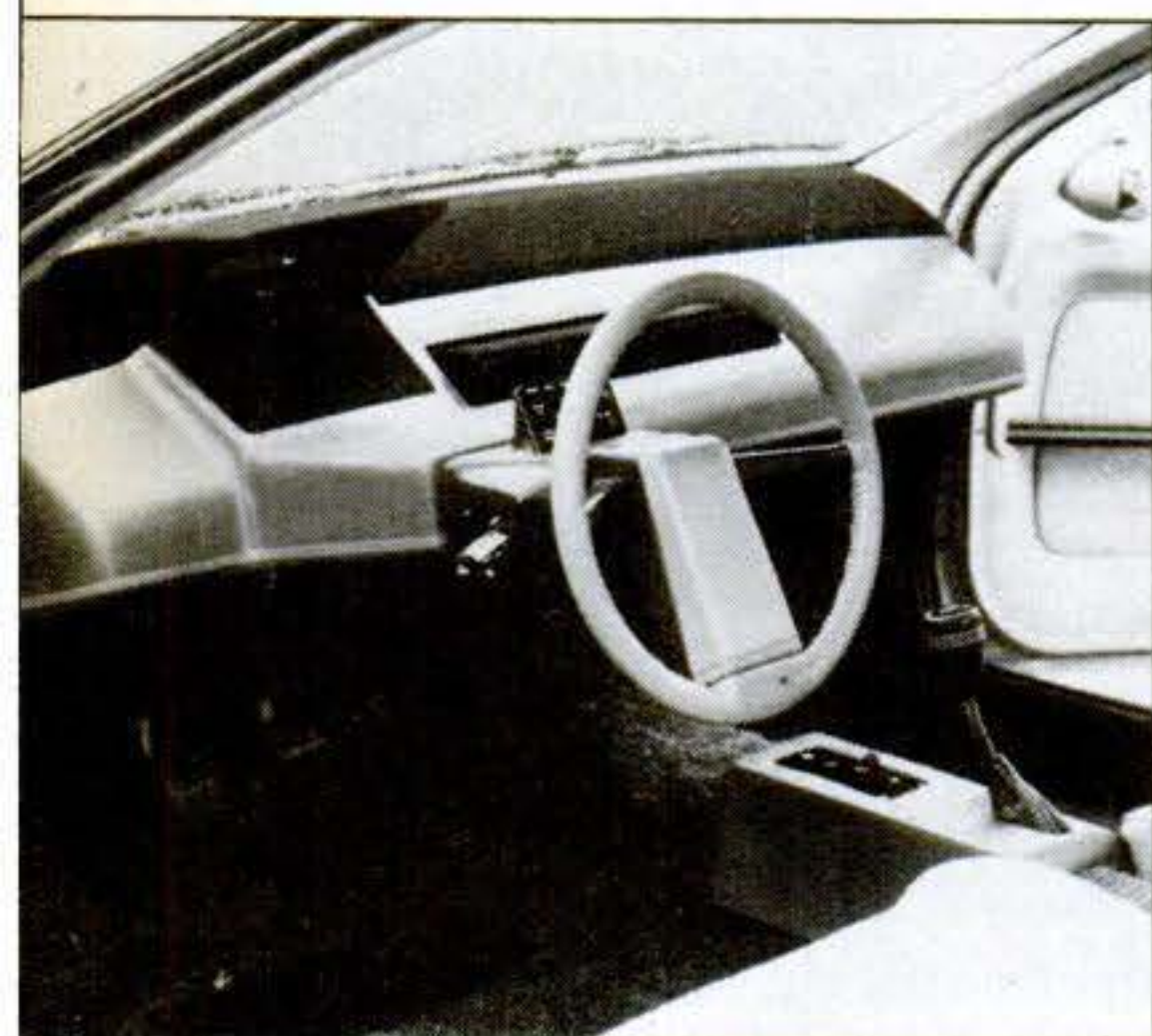
about 15 seconds," he said. "At 15 below zero it could take 35 seconds. On the other hand, it's a heat engine and is therefore more efficient in cold weather."

That's when he stepped on the gas and we shot out of the MTI driveway, stilling any doubts I had about the engine's acceleration. Once in traffic, Spraker demonstrated another of the Stirling's surprising virtues by pushing a series of buttons on the heavily instrumented dash. "I'm switching from unleaded gas to diesel fuel to gasohol as we go," he explained. "This engine doesn't care what it runs on." Indeed, I couldn't feel the slightest change in performance, and the dials on the panel didn't even quiver as he varied fuels.

All of this was very impressive, but one big question remained: What is the likelihood of a Stirling-powered car appearing in the showroom soon, in five years, or ever?

Unfortunately, that question is impossible to answer right now. Government cutbacks have placed the third phase of the NASA program in doubt. Although the Mod I engine is well on its way to demonstrating all it was expected to and more, its planned successor, Mod II, is presently condemned to remain a "paper" engine. Perhaps a car manufacturer will pick it up and carry on. If not, a great deal of successful research may languish half finished. After seeing the performance of the NASA Stirling at this stage, I'd hate to see that happen. **ES**

95-mpg commuter car from GM



Aerodynamic styling of TPC keeps drag to a minimum (top). Above: long steering



column allows more leg room. Radio and clock are controlled from column panel;

lights, wipers from signal stalk. Right: TPC compared with production Chevette.

Prototype micro-mini isn't going into showrooms, but some of its features might

By **CHARLES A. MILLER**

The first question I had as I lowered myself into the driver's seat of GM's TPC (two-passenger commuter) was: "Am I going to have enough power to get this thing out of its own way?" Dale Johnson, director of GM field-products engineering, assured me that power was no problem—after all, the car only weighs half a ton, and because of its experimental status, it's unencumbered by power-sapping emission controls.

I gripped the wheel and shifted into gear. As we pulled out, the engine backfired but moved the little car through traffic briskly.

The TPC is GM's micro-mini engineering prototype that resembles the tiny cars produced in Japan [PS, June '82]. On EPA test cycles with two passengers and 44 pounds of cargo, it gets 68 mpg in city driving and 95 on the highway.

The front-wheel-drive TPC is powered by an aluminum three-cylinder, 0.8-liter (48.8 cu. in.) gasoline engine linked to a five-speed transaxle.

Most of the body is high-strength, thin-gauge steel, but the doors, front end, and four-wheel drum brakes are aluminum. The suspension system

consists of transverse, reinforced-fiberglass springs.

As small as it is (33 inches shorter and five inches narrower than a Chevette), there is ample room inside. GM claims that the front-seat area has more room than a Chevette.

The TPC's drag coefficient is 0.31, thanks to its smooth underbody, flush glass, integral air dam, and flush wheel covers and tires. Interior ventilation air exhausts from beneath a roof extension over the top of the rear hatchback. The design keeps the air-flow closer to the car's rear and reduces drag.

GM has no plans to market the car. However, some of its features could show up in future vehicles. **ES**

Robot repair crew for 7,000-ft.-deep pipeline

A clever connector and remote-controlled submarines make deep-water pipelines possible

By DAVE EMANUEL

ILLUSTRATION BY DEAN ELLIS

"It's a tricky operation," said Derek Sidwell of Cameron Iron Works in Houston, Tex. "We can't use conventional pipe-laying methods much below 2,000 feet."

Sidwell was describing the difficulty of laying a proposed 100-mile-long natural-gas pipeline from Spain to Algeria. There's much red tape to untangle before the \$100 million pipeline—a joint project of the two nations—becomes a reality. But the first obstacle was to determine whether it was even possible. To cross the Mediterranean the pipeline must descend to the unprecedented depth of 7,000 feet beneath the sea.

"At those depths," said Sidwell, "pressures reach over 3,000 pounds per square inch. The weight of the pipe itself becomes a factor during construction."

To withstand the pressures, extra-strong alloyed steel must be used for the pipe sections. Welding this steel is tricky and time-consuming. And even this tough pipe can buckle as it's lowered to such depths. "A 16-inch-diameter pipe with a one-inch-thick wall can collapse like a drinking straw flattened between your fingers," said Sidwell.

Worse still, divers can't reach a pipe laid this deep. And no company will finance or insure a pipeline that can't be repaired.

Sidwell says these problems can be solved by Cameron's advanced technology. The company has responded to the requests for proposal issued by the Mediterranean Pipeline Commission. The key element in Cameron's problem-solving proposal is a deceptively simple component: a new pipe connector that will cut construction time in half and make deep-sea repairs possible.

The new connector screws onto the pipe sections—eliminating the difficult welding job. New pipe sections can be joined in less than 10 minutes, compared with the 15 to 20 minutes needed for welding. Halving construction time cuts costs significantly. It also means the contractor doesn't have to shut down during winter, so he can finish construction in one season. The new connector also strengthens the pipe joints and helps to prevent the

pipeline from buckling as it is lowered to the sea floor.

Screw-together pipeline connectors have been used for several years, so the concept is not revolutionary. But unlike other connectors, Cameron's version has a double seal and needs no gasket. The connector's most outstanding feature is a set of external flanges that serve as docking stations for repair vehicles. These flanges also make it possible to seal the pipeline tightly after repairs.

"Nobody has ever made a screw-together, metal-to-metal sealing connector that also functions directly as a pipeline repair tool," said Sidwell. "A patent is pending on this design."

Repairs aren't a major problem for most undersea pipelines. In shallow waters, a team of divers can go below to fix most damage. Many times, the entire repair operation can take place underwater. Sometimes a diver removes a section of pipe and brings it to the surface for repair. But at 7,000 feet down a different technique is needed.

One approach is to simply abandon a damaged pipeline and lay a replacement. In effect, this was done with the first trans-Mediterranean pipeline. This runs between Algeria and Italy at a depth of 2,000 feet below sea level.

The builders laid a spare pipeline. If one of the primary lines is severely damaged, it will be shut down and the spare used in its stead. Although a straightforward solution, this technique is outrageously expensive.

"Our proposal states that we'll use remote-controlled vehicles [RCV's] for repairs," said Sidwell. "These RCV's are electronically controlled from the surface through an umbilical cord." RCV's are currently used successfully for deep-water drilling and a variety of other subsea applications [PS, Dec. '81].

Cameron proposes to use several RCV's for the repair (see overleaf). Though repairs haven't been tried at such depths, Sidwell is confident the scheme will work.

"It's quite a viable concept," he says. "Cameron has already used similar technology in other areas. Likewise, the collet connectors and swivels [see diagram] have been used in other subsea applications. We've seen nothing in our initial testing to indicate the concept won't work."

Cameron's screw-together connecting-and-repairing system could also be instrumental in opening up new oil and gas fields. For example, an oil field recently discovered off the coast of California lies at a depth of 2,500 to 3,000 feet. With a deep-water pipeline, the oil could be pumped directly to a refinery—cutting costs significantly. ■

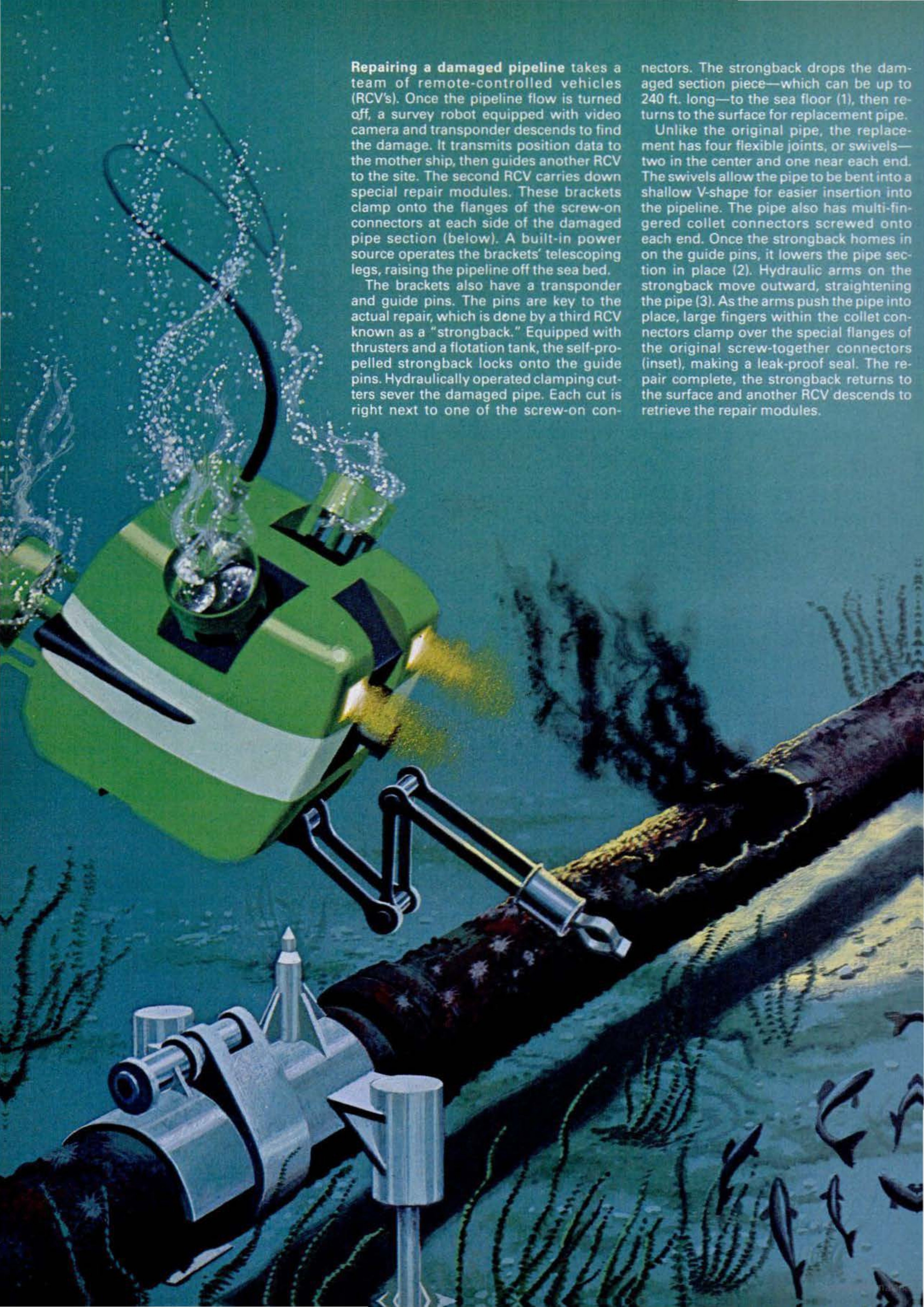
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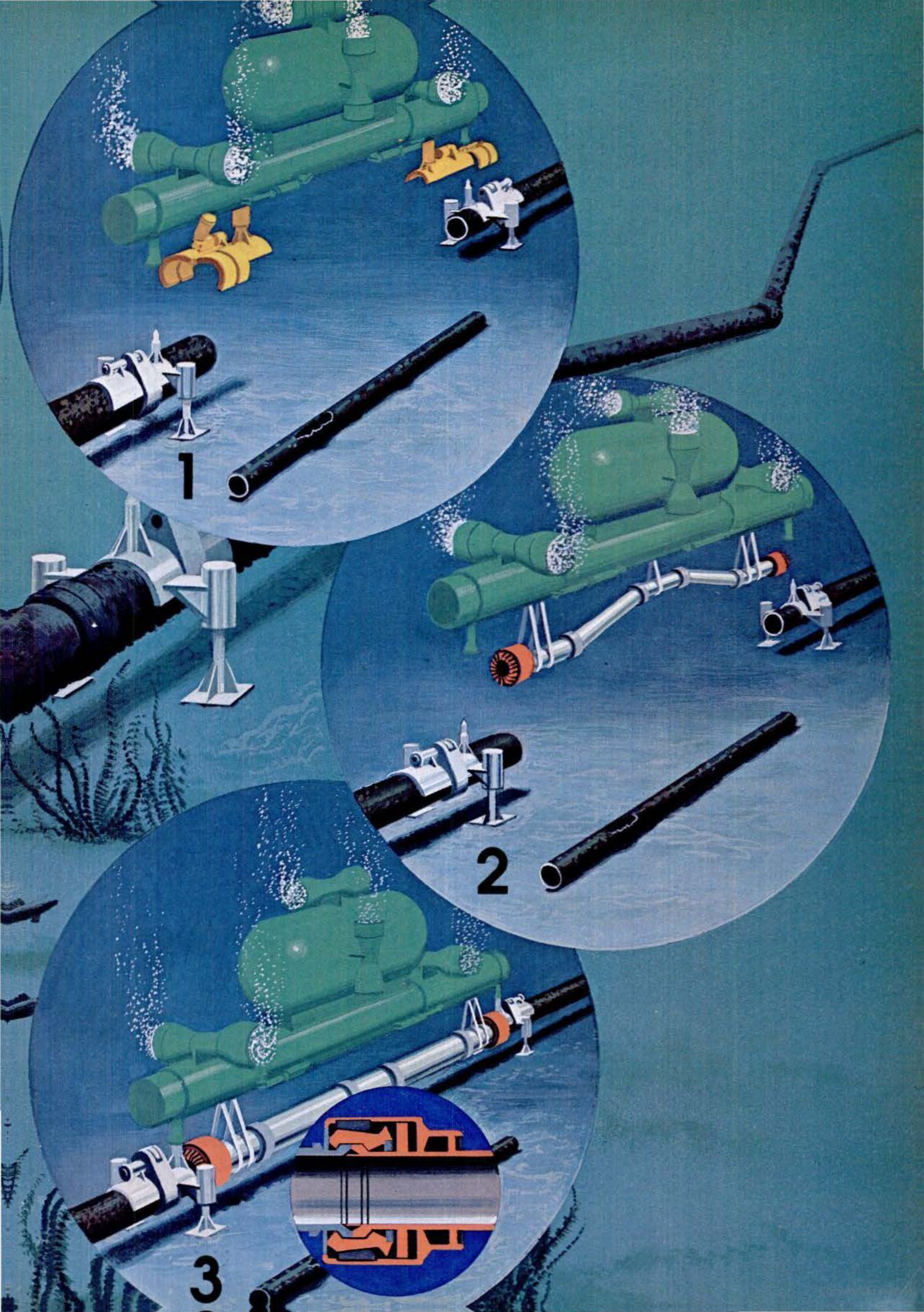
Repairing a damaged pipeline takes a team of remote-controlled vehicles (RCV's). Once the pipeline flow is turned off, a survey robot equipped with video camera and transponder descends to find the damage. It transmits position data to the mother ship, then guides another RCV to the site. The second RCV carries down special repair modules. These brackets clamp onto the flanges of the screw-on connectors at each side of the damaged pipe section (below). A built-in power source operates the brackets' telescoping legs, raising the pipeline off the sea bed.

The brackets also have a transponder and guide pins. The pins are key to the actual repair, which is done by a third RCV known as a "strongback." Equipped with thrusters and a flotation tank, the self-propelled strongback locks onto the guide pins. Hydraulically operated clamping cutters sever the damaged pipe. Each cut is right next to one of the screw-on con-

nectors. The strongback drops the damaged section piece—which can be up to 240 ft. long—to the sea floor (1), then returns to the surface for replacement pipe.

Unlike the original pipe, the replacement has four flexible joints, or swivels—two in the center and one near each end. The swivels allow the pipe to be bent into a shallow V-shape for easier insertion into the pipeline. The pipe also has multi-fingered collet connectors screwed onto each end. Once the strongback homes in on the guide pins, it lowers the pipe section in place (2). Hydraulic arms on the strongback move outward, straightening the pipe (3). As the arms push the pipe into place, large fingers within the collet connectors clamp over the special flanges of the original screw-together connectors (inset), making a leak-proof seal. The repair complete, the strongback returns to the surface and another RCV descends to retrieve the repair modules.

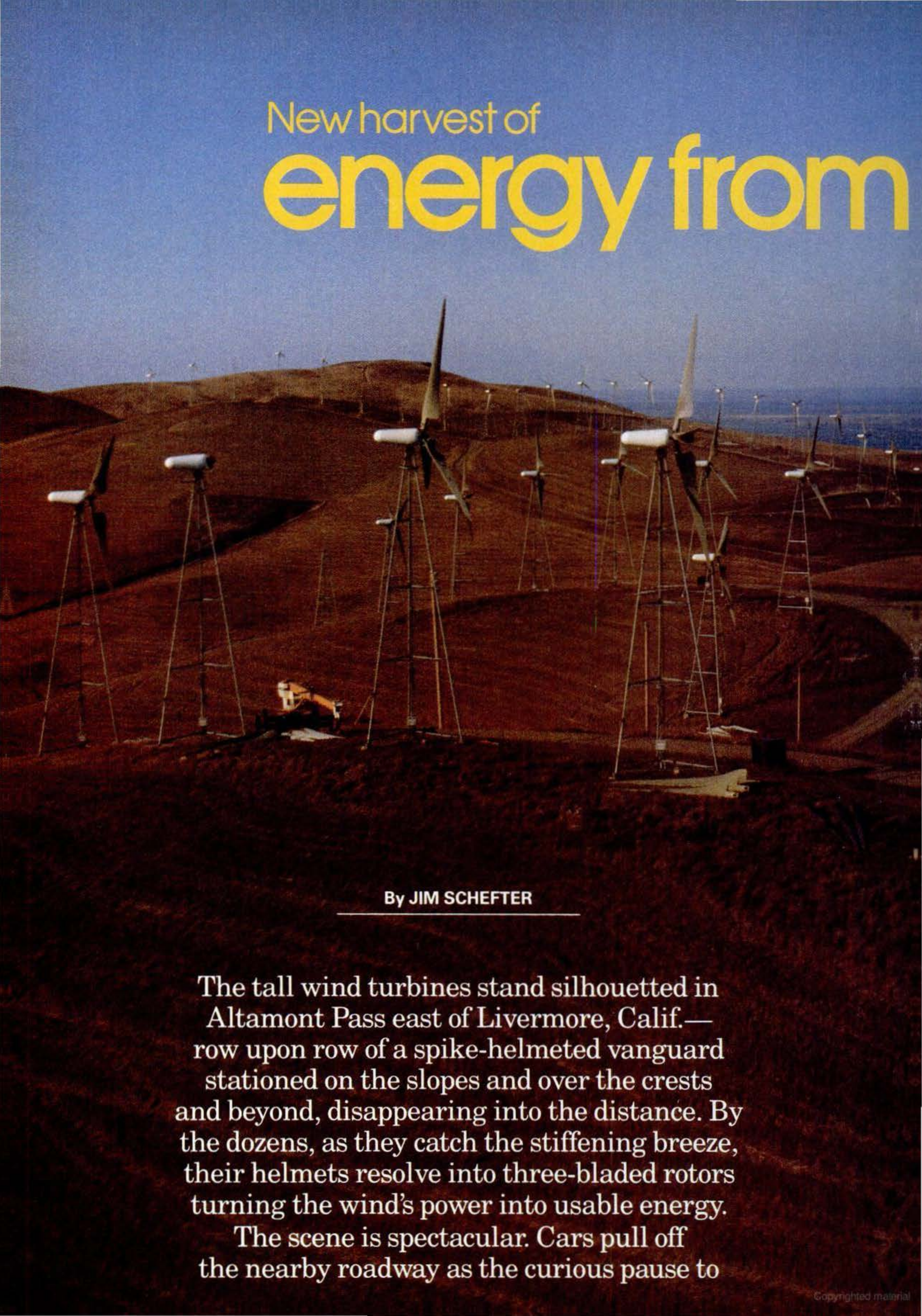




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New harvest of energy from

By JIM SCHEFTER

The tall wind turbines stand silhouetted in Altamont Pass east of Livermore, Calif.—row upon row of a spike-helmeted vanguard stationed on the slopes and over the crests and beyond, disappearing into the distance. By the dozens, as they catch the stiffening breeze, their helmets resolve into three-bladed rotors turning the wind's power into usable energy.

The scene is spectacular. Cars pull off the nearby roadway as the curious pause to

wind farms



look. A few linger, recognizing that they see something of the future—a working wind farm of 100 turbines producing electricity day in and day out, enough to supply millions of kilowatt-hours to the local power grid.

But the project, built by U.S. Windpower, San Francisco, Calif., is only part of a growing industry. Not far away, flanking and spanning more hills in the windy pass, 50 Fayette Manufacturing Corp. (San Raphael, Calif.) turbines harvest the breeze. At still another hilltop only minutes away stand the first five of several hundred turbines planned by Sacramento's WindMaster Corp. And at other sites throughout the Altamont Pass, which connects the cool San Francisco area with the hot San Joaquin Valley, more wind farms are planned or under construction. As many as eight sites could be operating here before the year is out, experts say.

Still others are springing up far to the south in California's Tehachapi Mountains, and sites are being evaluated in

Montana, Wyoming, New Hampshire, and elsewhere. All call for turbines in the 50-kilowatt class, though smaller, 12-kW machines are being installed at three wind farms in Hawaii.

The north coast of Oahu and a windy ridge in Solano County, Calif., were to have been the sites for massive wind farms using the 2.5-megawatt machine developed by the Boeing Company. But the twin blows of high interest rates and an oil glut put the projects on indefinite hold. The field, at least for now, belongs to the smaller, less-expensive turbines.

The wind-farms concept was kicked around through the energy crunch of the mid-'70's. Suddenly, in 1982, the idea blossomed into fact. What happened?

"Of all the emerging alternate-energy technologies, wind is the closest to true commercialization," said James H. Malinowski, manager of Pacific Gas and Electric Co.'s generation planning department. PG&E buys all the power

Continued



Upwind turbine in top photo, operated by WindMaster, is built in Europe by HMZ Corp. You get to the top by climbing a ladder inside the 72-foot tower. In an average wind of 16 mph, one machine alone could provide power enough for 20 homes. Bottom: Fayette project has 200 downwind turbines scheduled for installation. The 50 machines now in operation provide enough electricity to power approximately 1,100 homes.

PHOTOS BY AUSTIN & WEST PHOTOGRAPHY

that can be produced by the wind farms; utilities are required to do so by federal law, but PG&E has moved more aggressively than most to help foster the new wind-power industry.

That attitude by PG&E and other utilities, including Southern California Edison, feeds growing excitement in the still-fragile wind industry. As more wind farms tie into local power grids, both utilities and operators are gaining experience.

"The alternate energy we're going to understand first is wind power," said Edgar A. DeMeo, manager of solar-power systems at the Electric Power Research Institute (EPRI) in Palo Alto, Calif. The institute, funded by private electric utilities, sponsors a broad spectrum of related research. "By 1986 or possibly earlier," DeMeo continued, "we're going to know exactly what role wind can play in generating utility power."

Wind-energy technology advanced rapidly in recent years, sparked by a joint NASA-Department of Energy program and by industrial research and development. It's an ironic turnabout; the federal Rural Electrification Administration virtually killed the wind-energy industry in the 1930's and '40's by requiring many farmers to take down their wind turbines as a condition to getting an electric hookup. That put a brake on research, at least until the energy crunch.

Progress in wind technology

An effective wind turbine is not just another windmill. "There's new technology involved," said Dr. Frank R. Goodman Jr., project manager for wind-power systems at EPRI. "There are structural dynamics, control systems, aerodynamic design, and new materials to be considered," he said. Since a wind turbine must operate for 25 to 30 years with minimal maintenance and survive in extreme weather, all factors become critical—and none is yet perfected.

But wind-turbine technology recently came to a point where it straddled the fence of economic success. The fledgling wind industry needed only a catalyst to plunge ahead with commercial projects. It got that from federal and state energy tax credits, which can amount to between 40 and 50 percent of the capital investment, and from a 1978 law requiring utilities to buy electricity from independent producers. (Utility companies are not eligible for the energy tax credits.)

Utilities must pay on a basis called "avoided cost"—the cost they would otherwise pay to generate the power with their most expensive fuel. The avoided cost has been running 5.3 to seven cents per kilowatt-hour at PG&E. That's not close enough to the break-even point for small 50-kW wind turbines, which generally have an overall cost of 11 cents or more per kWh of electricity. But with the tax credits, it's expected to make most wind farms profitable. And new money flowing in allows wind-turbine manufacturers to continue improving their machines.

The Fayette Manufacturing Corp. and U.S. Windpower dominate the field today. Both were formed to manufacture and install wind-farm turbines. Neither wants to sell individual machines. WindMaster, the third company in Altamont Pass, imports its machine, tower and all, from Belgium.

Fayette's machines are poised on slender, aesthetically pleasing tubular towers that vary from 40 to 60 feet high. The height disparity came about because company president John Eckland worried that wake turbulence from one machine could affect the next. (After six months of experience in Altamont Pass, he quit worrying and adopted the 40-foot tower as standard.)

U.S. Windpower designed its own tower, a three-legged

pyramid of four-inch galvanized pipe standing 60 feet tall. "We wanted to minimize the tower shadow," said Sandra Bodmer-Turner, vice-president for project development.

In wind-energy parlance, the "shadow" is the change in velocity (or the turbulence) experienced when wind passes the tower. The shadow can cause undue stresses on rotating blades, set up destructive harmonic vibrations between the tower and blade, or otherwise bring adverse effects to turbine operation.

The U.S. Windpower tower isn't pretty, but it works. There have been no shadow problems.

The European-built WindMaster is an upwind turbine, facing into the breeze. Since it doesn't have a shadow factor to consider, its tower is among the largest used on wind farms. It stands 72 feet tall, is five feet in diameter at the base, and tapers to three feet at the top. Individual microprocessor controls are installed in the base.

A wind turbine's output is a factor of both its rating, or maximum output, and its power curve, which depends on wind speed. "Wind isn't a reliable resource because it comes and goes," PG&E's Malinowski said. "We have to distinguish between a wind turbine's rated capacity and what we call its 'firm capacity.'" Firm capacity is the amount of electricity generated over a period of time, in wind conditions ranging upward from zero. The WindMas-

“Wind farms, ideally, should be automatic. . . . Only maintenance chores would require a human presence”

ter power curve is typical. Its induction generator doesn't kick in until wind speed is about seven miles per hour. Then it produces three kW. In a 12-mph breeze, output is 12 kW. At 15 mph, it's 24 kW, and at 18.3 mph, it peaks at 44 kW. Fayette's machine peaks at 56 kW in 22-mph wind; the U.S. Windpower turbine peaks at 50 kW in 22-mph wind.

PG&E assumes the firm capacity of a wind farm—its average output—to be about 20 percent of rated capacity. Thus wind energy's strong point is not hour-to-hour reliability, but its overall contribution to the energy budget. "We think there's a potential for several thousand megawatts of firm capacity in our area alone," Malinowski said.

Wind farms, ideally, should be automatic. Turbines would begin moving in light breezes, and preprogrammed microprocessor control systems would feed electricity through meters into the utility lines when output reached selected levels. Only maintenance chores would require a human presence.

But automatic operation can only come about when the last technical bugs are worked out of turbine hardware and wind-farm operators get a few years of operating experience on components and systems.

Each of the major turbines installed in 1982 uses a different technique to harvest maximum energy from the wind. For instance, even though each turbine uses three fiberglass blades, designs are radically different.

Fayette's 50-foot-diameter fixed-pitch rotor has a broad, flat-end airfoil that resembles a light-aircraft wing. Wind sensors activate an electric motor that turns the nacelle-and-rotor assembly away from the wind. Pop-out spoilers in the blade tips are activated in a 60-mph wind, stalling

the blade to prevent damage to the generator, transmission, and hub assembly.

WindMaster's 69-foot-diameter blades have more taper, with curved tips. They are also aimed by wind sensors and an electric motor. The variable-pitch blades turn to a stall when the wind reaches 55 mph, and are backed up by an electrically activated brake.

U.S. Windpower's 56-foot-diameter blades resemble shark fins that emerge from an aluminum foot, then taper to an almost needlelike point. It's a free-yaw design that shifts in the wind without motor drives, but the blades are pitch-controlled to stall at 55 mph.

Which design is best? "They could all do the job," said an expert at EPRI. "Time will give us the answer."

In the first half-year of wind farming, both Fayette and U.S. Windpower encountered major problems with blades, including stress and fatigue cracks, along with warping. Machines were repeatedly shut down, and at one point most Fayette turbines stood without blades at all. (WindMaster was too new at this writing to have significant operating experience.)

But both companies quickly put design-engineering teams to work, and both found fixes that they believe will eliminate future problems. Fayette's trouble was traced to an internal spar in the blade that failed when gusty winds combined with the 84-rpm blade speed to set up stress vibrations. Redesigning the spar, coupled with increasing the rotor speed to 122 rpm, soon had the farm operating again.

A unique cast-aluminum foot that connects U.S. Windpower's shark-fin blade to the rotor hub didn't survive the stress of Altamont Pass wind shifts and gusting. Fatigue cracks developed; some blades were torn away and destroyed. Engineers discovered both inferior casting, which had somehow passed early testing, and unusual stress points at the foot's right-angle turn. They changed foundries, modified the foot design to add metal, and instituted a rigorous quality-testing program.

"Those kinds of things are going to happen with any emerging technology," said Windpower's Bodmer-Turner. "We're going to be making changes and improvements all along the way. But we're learning quickly."

Beginning with a banner year

U.S. Windpower's first 32 turbines came on line at the end of 1981. Then record-breaking winter rains virtually shut down construction at their site and most others. Even so, the company had its first complement of 100 turbines running in April 1982. By late July, that site had produced more than 1.5 million kWh of electricity and had accumulated 42,000 hours of turbine running time.

Fayette's 50 turbines generated 175,000 kWh in the same period, but increased to 277,000 kWh with all machines running in the windy months of August and September (1982). And WindMaster added another 75,000 kWh through September.

With that track record in the first year of wind farming, the industry gained significant credibility. But the federal government chose 1982 to sharply reduce its own wind-energy program, putting continued development of large wind turbines in jeopardy. Those machines were expected to have even more impact than the smaller units now operating, in view of the success of utilities like PG&E.

If the federal government continues to reduce its participation in large-wind-projects research and development, the future of wind power will belong to small-machine producers. They say they're ready. "You've got to have equipment that works, or the risk is too great," said Bodmer-Turner. "But the technology has settled down. Now it's a serious business."

What's New

A PICTURE ROUNDUP OF NEW PRODUCTS AND DEVELOPMENTS



Headband goggles

Solarband, an adjustable headband with goggles, is suitable for all seasons. The goggles can be worn on snowmobiles or tennis courts, but they're designed more for fashion than protection, says National Hydron Inc. (1764 Rohrerstown Rd., Lancaster, Pa. 17601).



Spy chopper

Two 63-inch rotors on the British ML Sprite propel this miniature radio-controlled helicopter at 60 knots. Twin six-hp engines power it. The sensor pack being installed can house a TV transmitter or other gear. It's made by ML Aviation Co. Ltd. in England.

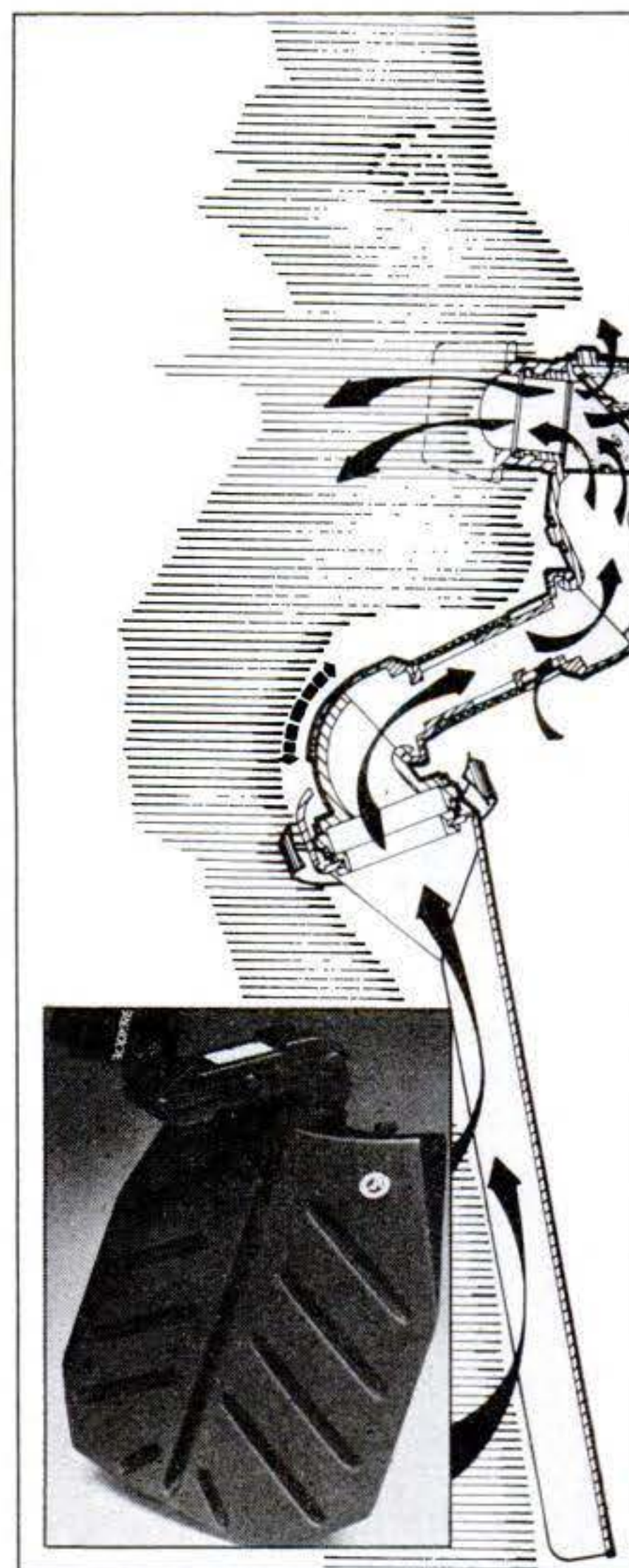
Air warmer

Inhaling freezing air while you jog can be uncomfortable. Bodybreather's chest shell warms air with body heat. A one-way valve ensures you won't re-breathe stale air, channeling used air into the atmosphere, says Xinox Corp., 85 Watermill Lane, Great Neck, N.Y. \$50.19.



Trolley bus

Flip a switch in Renault's PER 180 bus and it becomes an electric trolley. The articulated vehicle has a rear-mounted 245-hp diesel engine, plus a mid-mounted electric motor. A chopper converts DC from overhead wires into AC. One is being tested in Seattle, Wash.



Peugeot diesel

A five-passenger sedan, Peugeot's Vera research vehicle achieved 92.2 mpg in a 516-mile trip from Detroit to Knoxville, Tenn., last fall. Vera is powered by a 1.36-liter, 62-hp turbocharged diesel engine. Spoilers help cut the drag coefficient to 0.31.



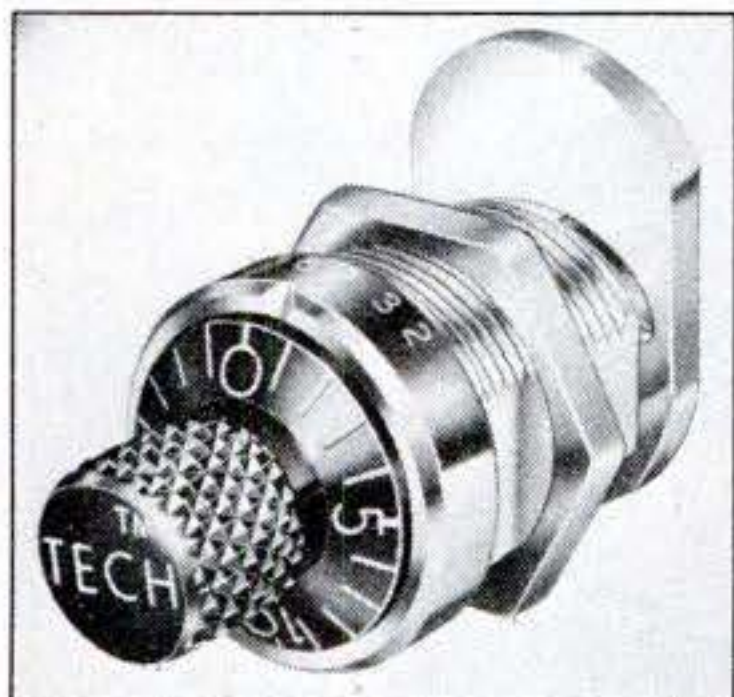
Solar-cell roof

An earth-sheltered home with a 4.5-kW array of photovoltaic panels on its roof was completed in southeastern Massachusetts. The privately financed home, designed by Solar Design Assoc. of Lincoln, Mass., produces surplus electricity that's sold to a local utility.



Orbital launcher

This January, the space shuttle Challenger is scheduled to ferry another vehicle into space to boost payloads into higher orbits. The Inertial Upper Stage vehicle, built by Boeing Aerospace, is shown with NASA's geosynchronous-orbit tracking-and-data-relay satellite.

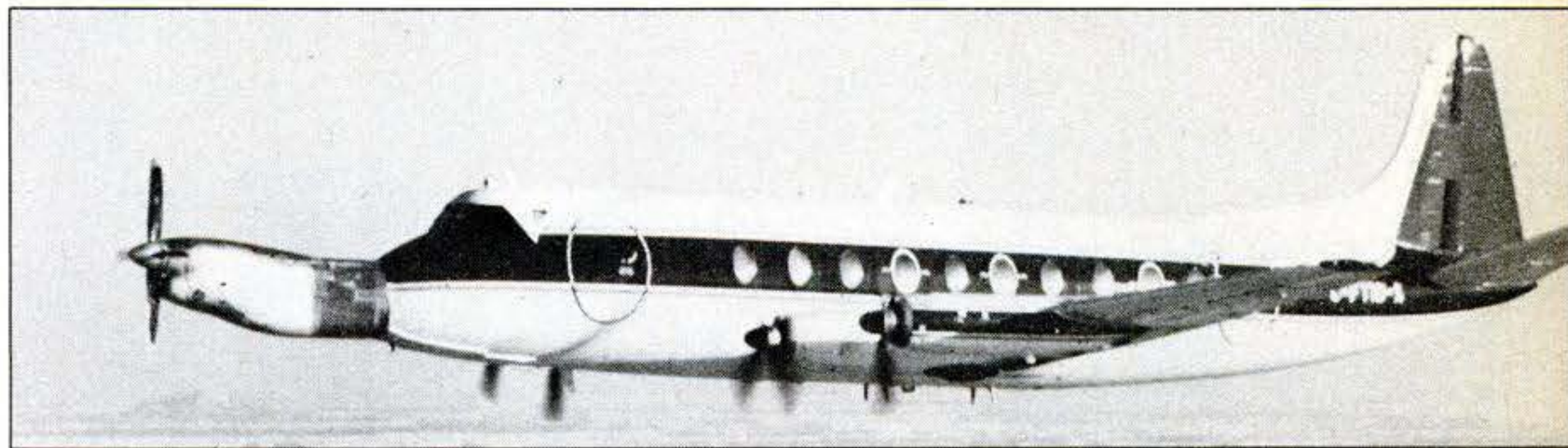
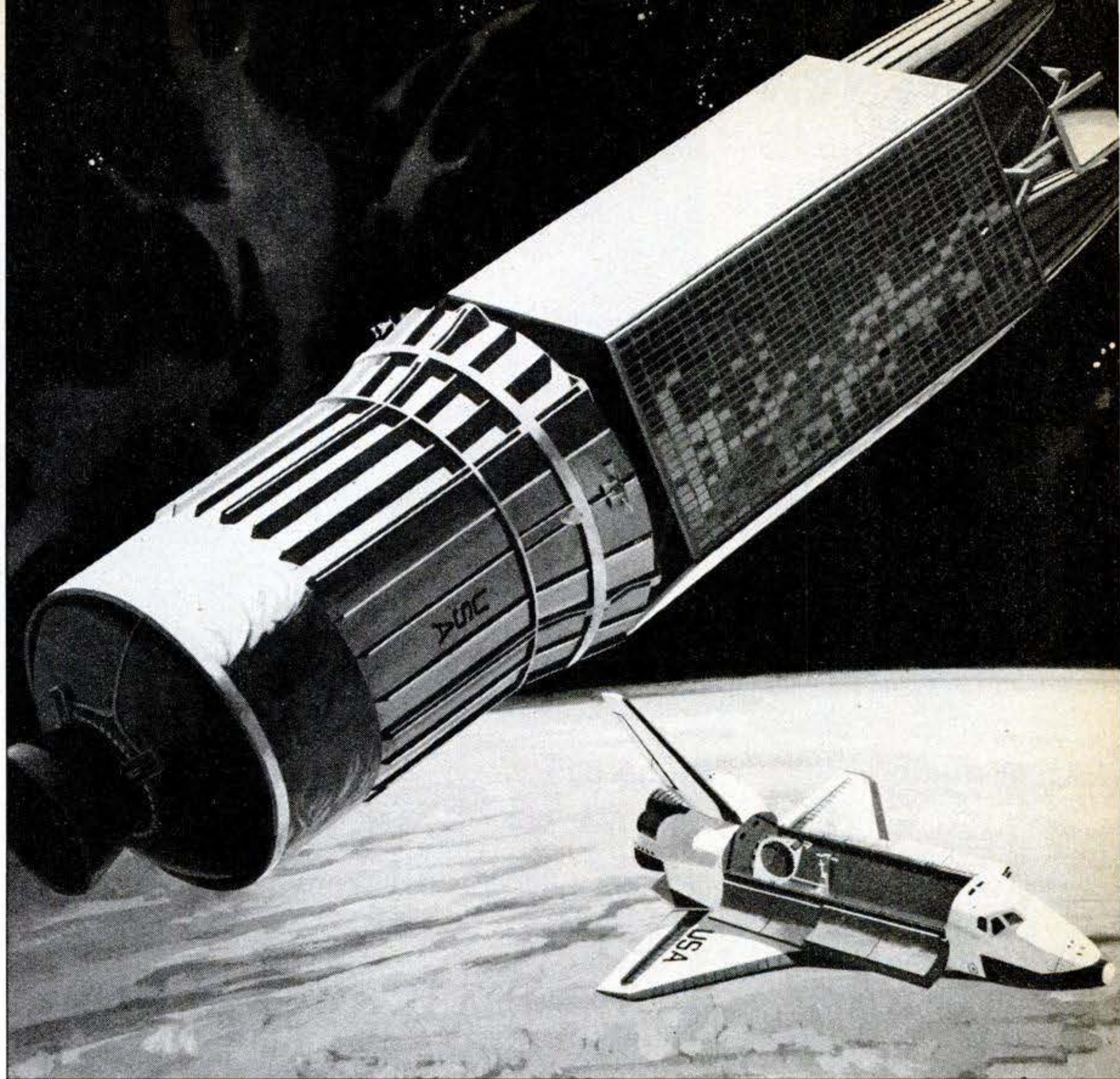


Cam lock

Substituting its combination cam lock for ordinary keyhole cam locks minimizes the risk of vandalism and theft, says Tech Manufacturing (Box 88, Rockford, Minn. 55373-0088). The 5/8-in.-long device quickly replaces any standard 3/4-in.-dia. keyed lock, says the maker. \$12.90.

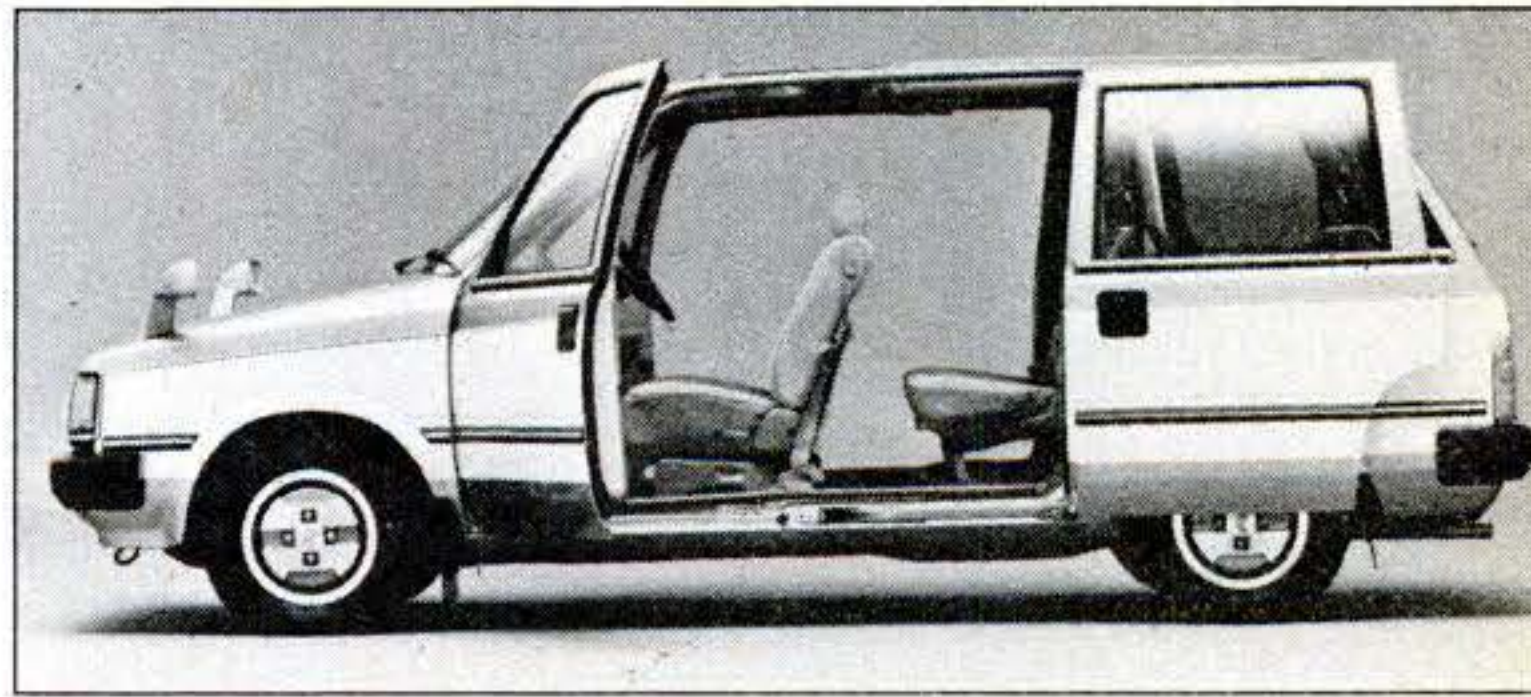
Snoopy plane

A long snout on this vintage four-turboprop Viscount airliner carries a new-generation Pratt & Whitney (Canada) engine for tests. The flying test bed lets engineers check the prop system as well as the engine, which has several features to increase its lifetime on commuter planes.



Automatic inverter

Winco inverters feature automatic starting when converting DC battery power to 120-volt AC. This, says Dyna Technology, Inc. (7850 Metro Parkway, Minneapolis, Minn. 55420-1985), eliminates battery drain when power isn't needed. Capacity: 800 or 1,200 watts.



Wide tractor

Does soil compaction from tractor tires reduce crop yields? A 33-ft.-wide, 360-hp research vehicle will help U.S. Department of Agriculture scientists in Shafter, Calif., find out. Equipment for tillage or harvest is suspended from a chassis tool bar.

Nissan Prairie

Roominess of a cab-over-engine coach and driving performance of a passenger car—that's a new concept embodied in its front-wheel-drive Prairie, says Nissan Motor Co. The small car seats eight in a variety of arrangements. U.S. marketing plans have not been announced.

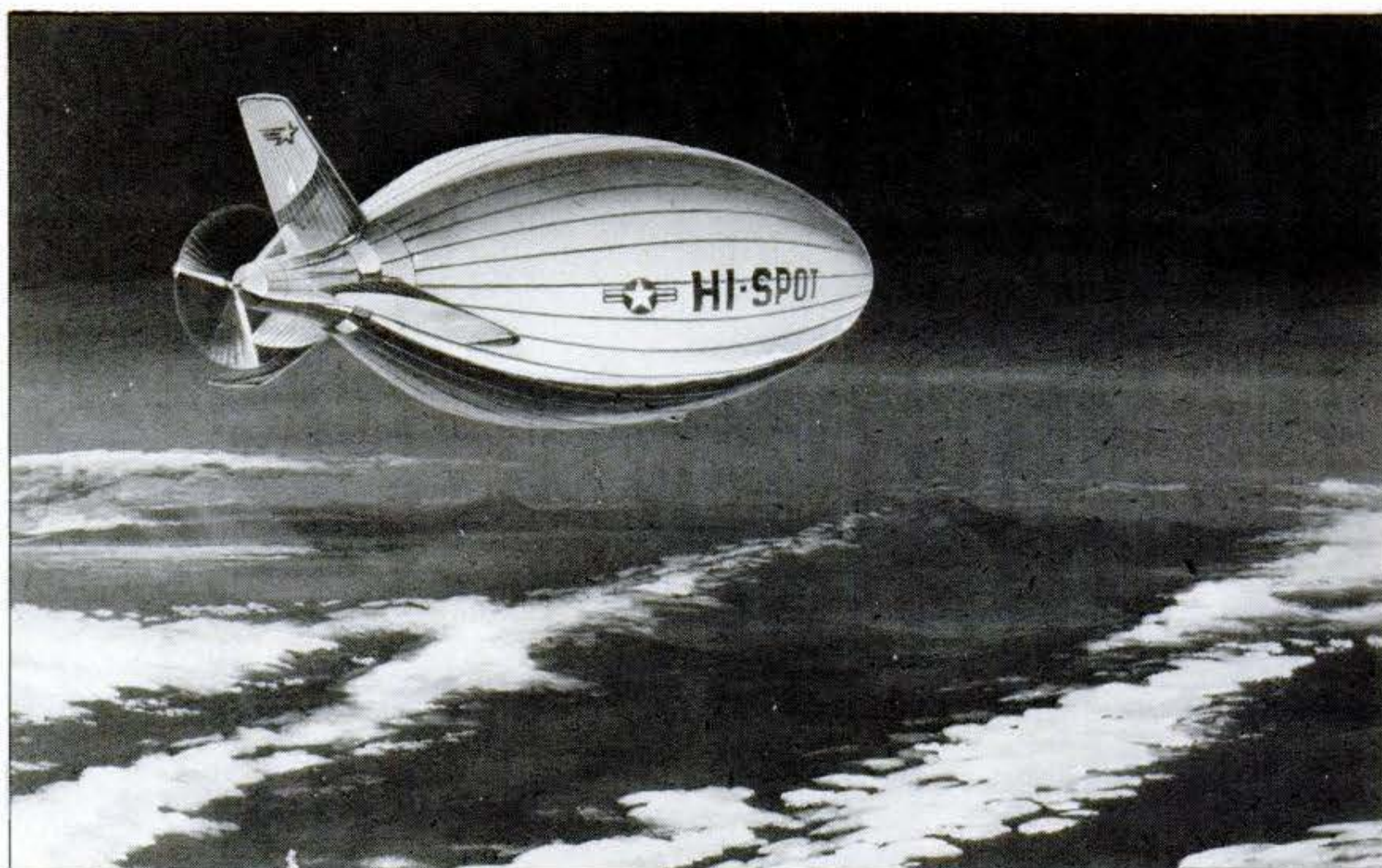


What's New



Gear guide

An inclino:meter for your bike, the Gear Tel shows the proper gear for the wind speed and your pedal power. It has five "pedaling intensity" settings. The self-contained unit clamps to a bike frame. Bicycle Prod., 36 W. 44th St., New York, N.Y. 10036; \$30.

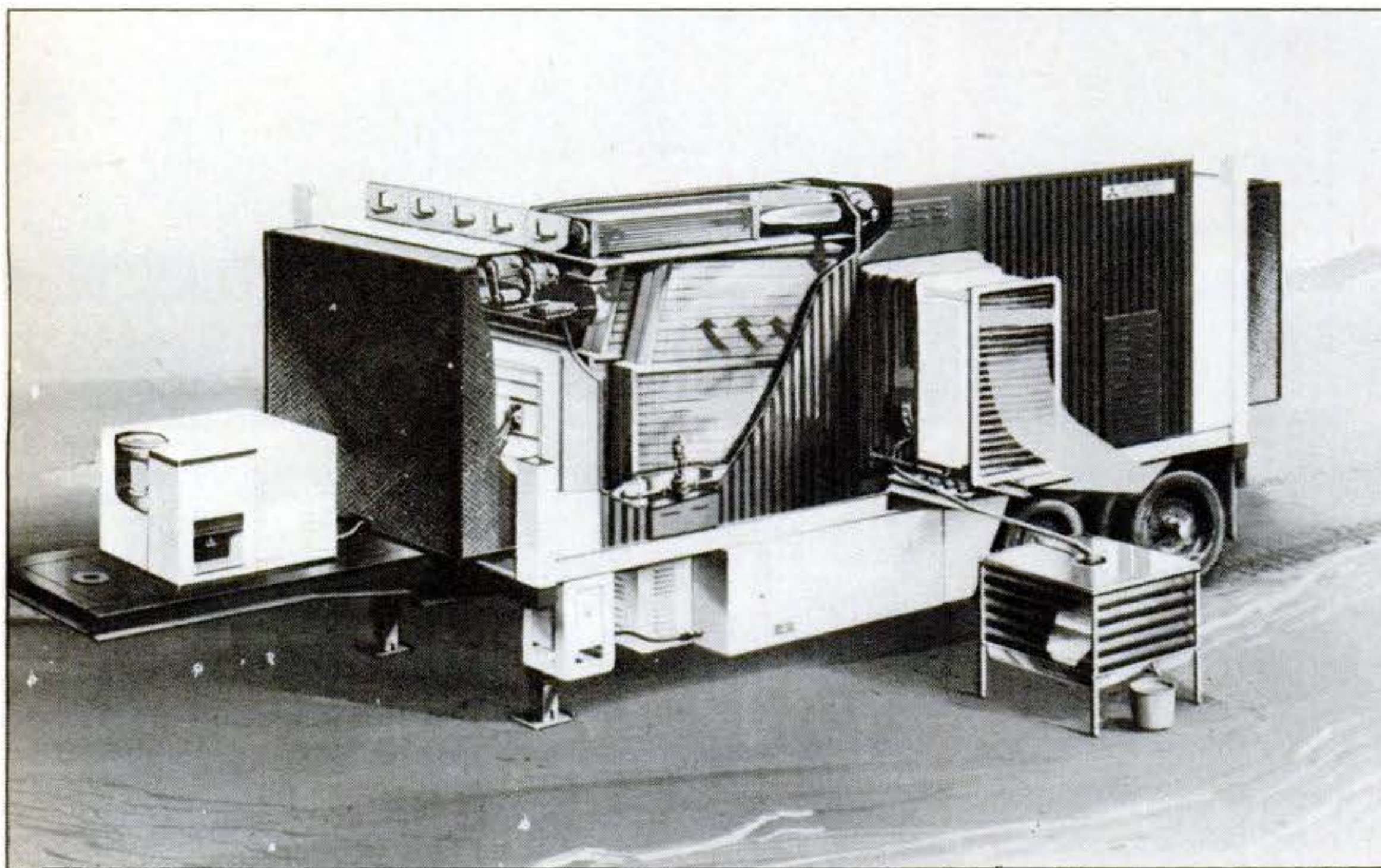


Blimp eye

Cheaper than a satellite, the 500-ft.-long Hi-Spot airship would hover 70,000 feet up for as long as 100 days. The tail rotor keeps it in one spot as the ship's payload carries out surveillance and communications. Lockheed designed the airship concept for the Navy.

Tennis test

When a ball slams into this racket, sensors wired to the player's back and chest record every twitch. The purpose: to test the racket's special vibration-absorbing properties. The new racket should help prevent tennis elbow, says maker, Rossignol Ski Co.



Water maker

Drinking water from thin desert air—that's what the Mobile Water Collection System provides. The collector converts ambient air moisture into steam, cools it, then purifies it to produce from 600 to 700 gal. per day, says Garjak Prod. (9666 Business Park Ave., San Diego, Calif. 92131).

Little Opel

The newest European mini-car, the Opel Corsa is GM's challenge to the Ford Fiesta, Renault 5, and other big-selling babies. The front-drive hatchback has a 93.7-in. wheelbase. Options include an all-new 1.2-liter, 55-hp, overhead-cam engine.



What's New IN PHOTOGRAPHY

BY E. H. ORTNER

Digital flash

Digital readouts make it easier to set Agfa's Agfatronic 643 flash, designed to work with dedicated cameras. It offers six apertures for auto operation—and even a TTL switch to transfer flash control to the camera. Guide number: 64 with ASA 100 film. List: \$298.



35-mm speedster

Twelve frames a second whiz through the Robot Star 50 D camera, claimed to be the "world's fastest 35-mm camera." A spring motor supplies power; electronic controls and electromagnetic shutter release set speeds to $\frac{1}{500}$ sec. Interchangeable lenses run from 30 to 150 mm.



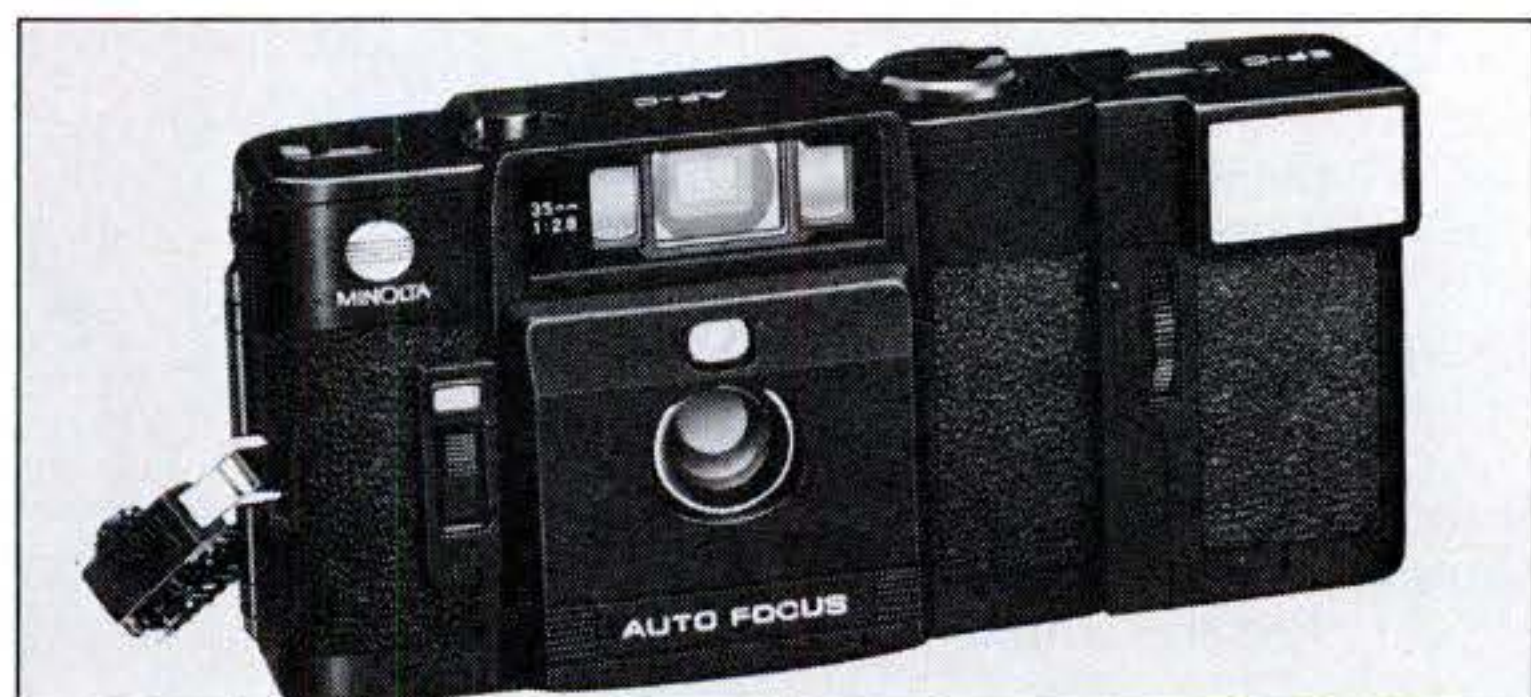
Autofocus SLR's

And still they come—more and more autofocus SLR cameras. At far left is the Olympus OM-F with Auto-Zoom 35-70 f/4 autofocus lens. Red and green LED arrows in the viewfinder indicate correct focus with any lens; with the 35-70, the camera automatically focuses the lens (and beeps to signal sharp focus). Camera: \$350; lens: \$380. Chinon, too, has a new 35-70 autofocus zoom lens (inset) to go with the Chinon CE-5 SLR. As with the Olympus, colored viewfinder indicators tell you when you're in focus and, with the automatic AF lens, an audible signal confirms it. Price and availability are not yet set.



2 1/4-inch projector

At last, say the Hasselblad makers, here's a 2 1/4-by-2 1/4 projector they approve of: their own. The PCP 80 uses a rotary-tray, gravity-feed system, offers a perspective-control lens to prevent screen keystone, and has two lamps—for automatic changing if one burns out.

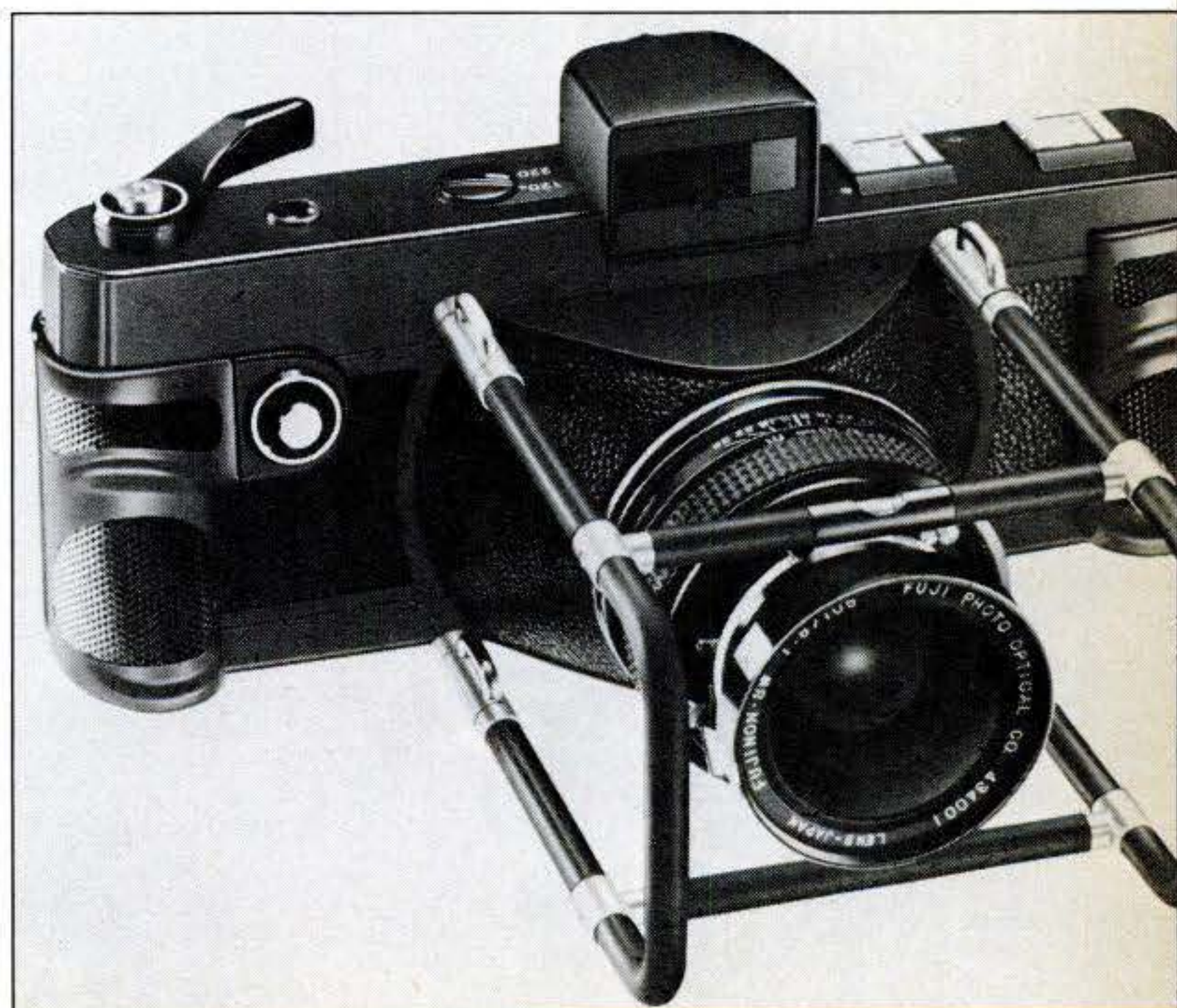


Compact AF

What's the smallest and lightest autofocus camera? The Minolta AF-C, says its maker. It weighs 7 3/4 oz. (plus two oz. for flash) and measures 4 1/8 by 2 1/16 by 1 5/8 in. A sliding shield protects the lens and locks the shutter. A green LED in the viewfinder indicates when subjects are within range.

Super-wide 120

Wide, wide angles are the specialty of Fujica's experimental Panorama G617 camera, designed for landscape, architectural, and aerial use. Its six-by-17-cm pictures on 120 film are almost three times the size of a medium-format six-by-six. The lens is an f/8 105. Availability: not yet.



What's New IN TOOLS

BY V. ELAINE SMAY



Smart router

A microprocessor-controlled router, one of a series of electronic tools Sears will introduce in June, selects the optimum cutting speed based on material hardness and bit size. It also detects feed rate and blinks a light if you should speed up or slow down. Price \$130.

Snow job

See-through cabs on a new line of snow throwers from Simplicity Mfg. Co. shield you from wind and snow. All three models (five, eight, and 10 hp) can clear even deep, wet snow and throw it 18 ft. up or 30 ft. out, says the maker. Snow throwers: \$850, \$1,060, \$1,280; cab: \$250.

Powerful portable

You'll pack the punch to drill in metal, wood, or plastic, or drive screws in or out when you take along the EZ 505 Rechargeable Drill/Driver, says AEG Power Tool Corp. (One Winnenden Rd., Norwich, Conn. 06360). It's got two speeds, four torque settings, and sells for \$150.

For long pulls

This hammer's built-in spacing rod, adjustable in 1/16-in. increments, gives you extra leverage to pull long or stubborn nails, it's claimed. A rubber cap on the rod protects the work surface. The tool is \$15 from Lamar Hammer, Inc., 3029 Fleetwood Ave., Baltimore, Md. 21214.



Hot strippers

These red-hot guns will take it all off—paint, that is—with a blast of heat instead of smelly, messy chemicals. Black & Decker's Heat 'N Strip electric paint remover has a maximum temperature of 480–570 deg. F, a two-year warranty, and costs \$40. He-jet heat gun (inset) from Pamran Co. (1101 Cedar Creek, Racine, Wis. 53402) gets even hotter: The model HJ-500 has a temperature range of 500–650 deg. F, draws only five amps, and costs \$66; the HJ-700 has a range of 700–1,000 deg. F, draws 8.3 amps, and costs \$70. Heat guns are useful for shrinking shrink tubing, drying projects, softening adhesives, and other jobs, as well as for paint stripping.



Pistol-grip brush

Molded-plastic handle on this Australian-made hog-bristle paintbrush is shaped to make painting easier, especially in awkward spots, and prevent fatigue. It will be distributed here by Decor Pal, Inc., 213 N. Lebanon St., Lebanon, Ind. 46052; three-in. size, \$10.

What's New IN HOME IMPROVEMENT

BY SUSAN RENNER-SMITH



Super shower

A shower feels like a waterfall with the Wet Set double-head system. Each head has only a 2.75-gpm flow, says Showerama (3612 Reese Ave., Riviera Beach, Fla. 33404). A switch converts the spray to a pulsating massage. \$40.

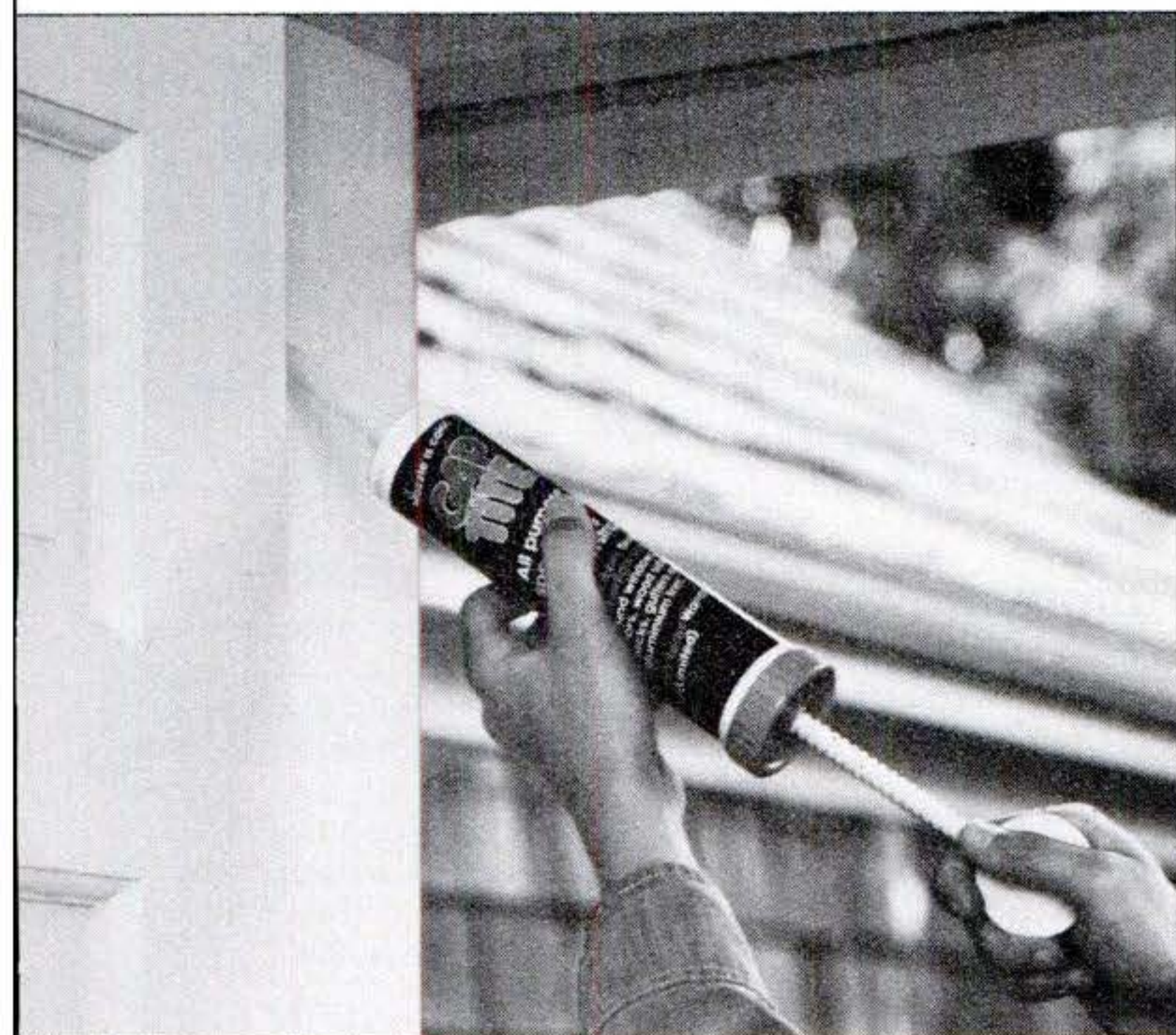
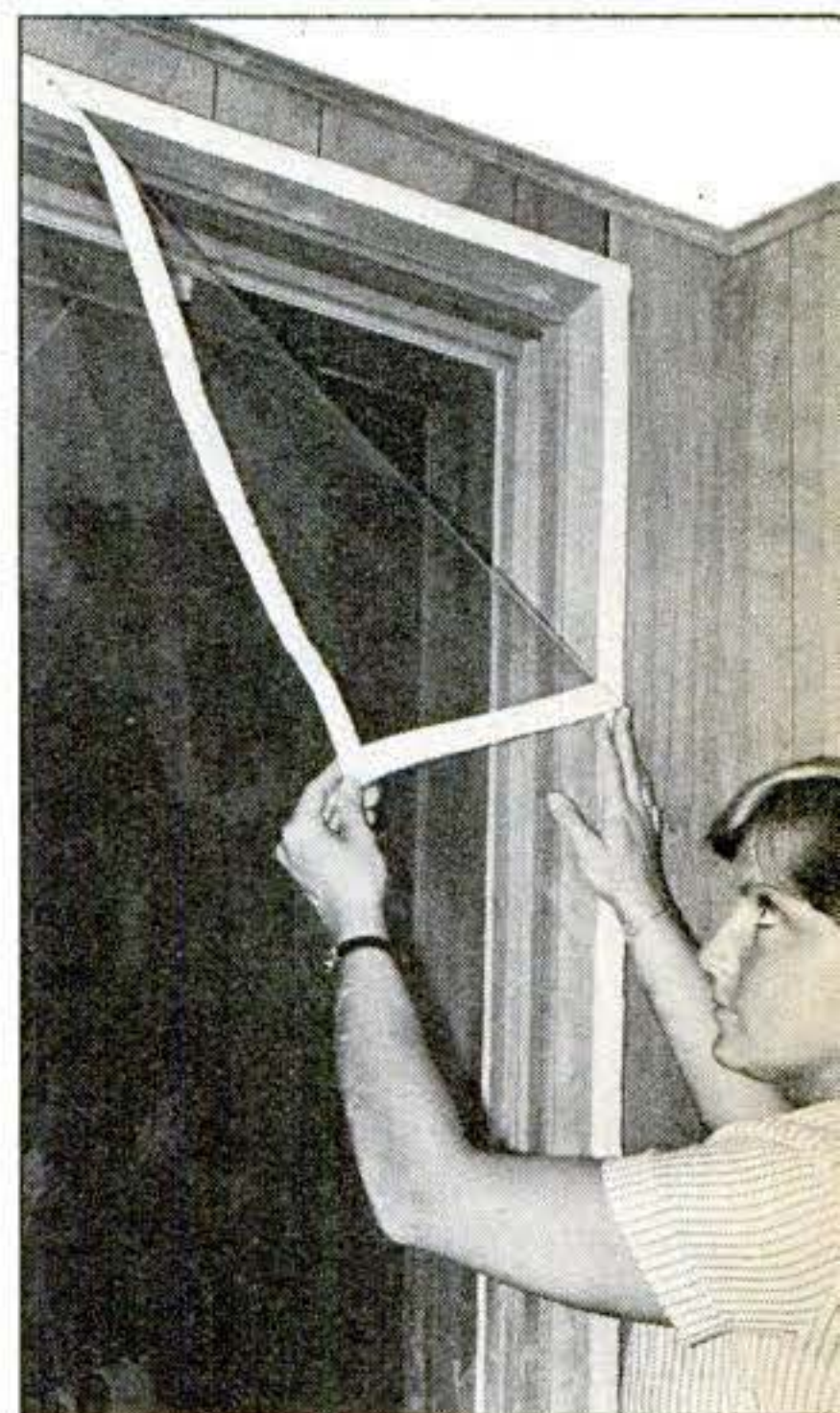
Draft detector

Forget just which outlets you've insulated? Thermo Guard's heat-sensitive tip detects tiny drafts and hidden insulation breaks. Temperature sensitivity is 0.04 degree. It costs \$20 from Metrifast, 51 S. Denton Ave., New Hyde Park, N.Y. 11040.



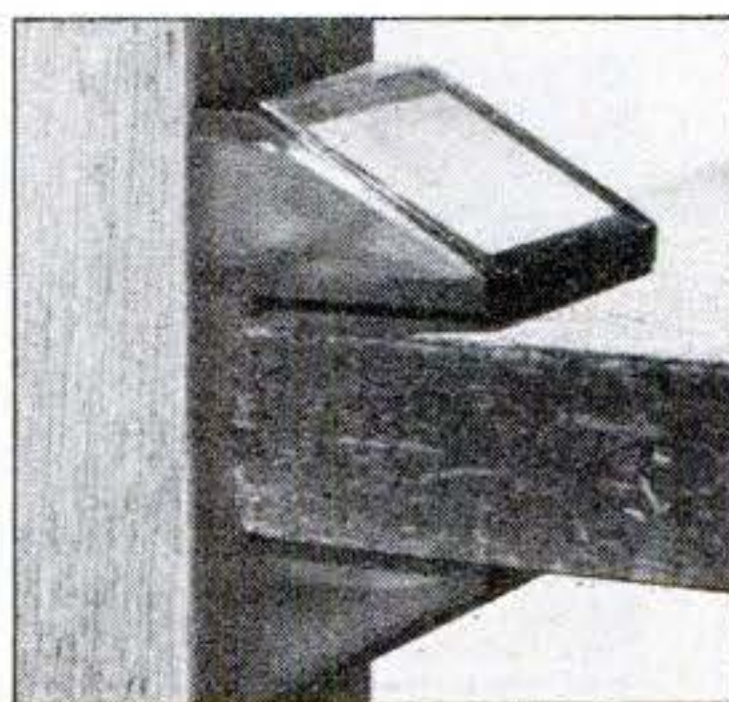
Resealable window

Draft-stopping plastic storms can make your house stuffy. A new press-on, peel-off version lets you crack open a window without removing the entire 20-mil plastic sheet. Energy Conservation Advisors (928 Spring St., Madison, Wis. 53715); \$1.70 a sq. ft.



Crack closer

A liquid weatherstrip with a 20-year warranty, GapTite takes the shape of the door (or window) jamb as it dries. The flexible silicone bead keeps out cold, dirt—even noise, claims the maker (Gedurit Chemical, Box 1245, Northbrook, Ill. 60062). A two-door kit costs \$12.

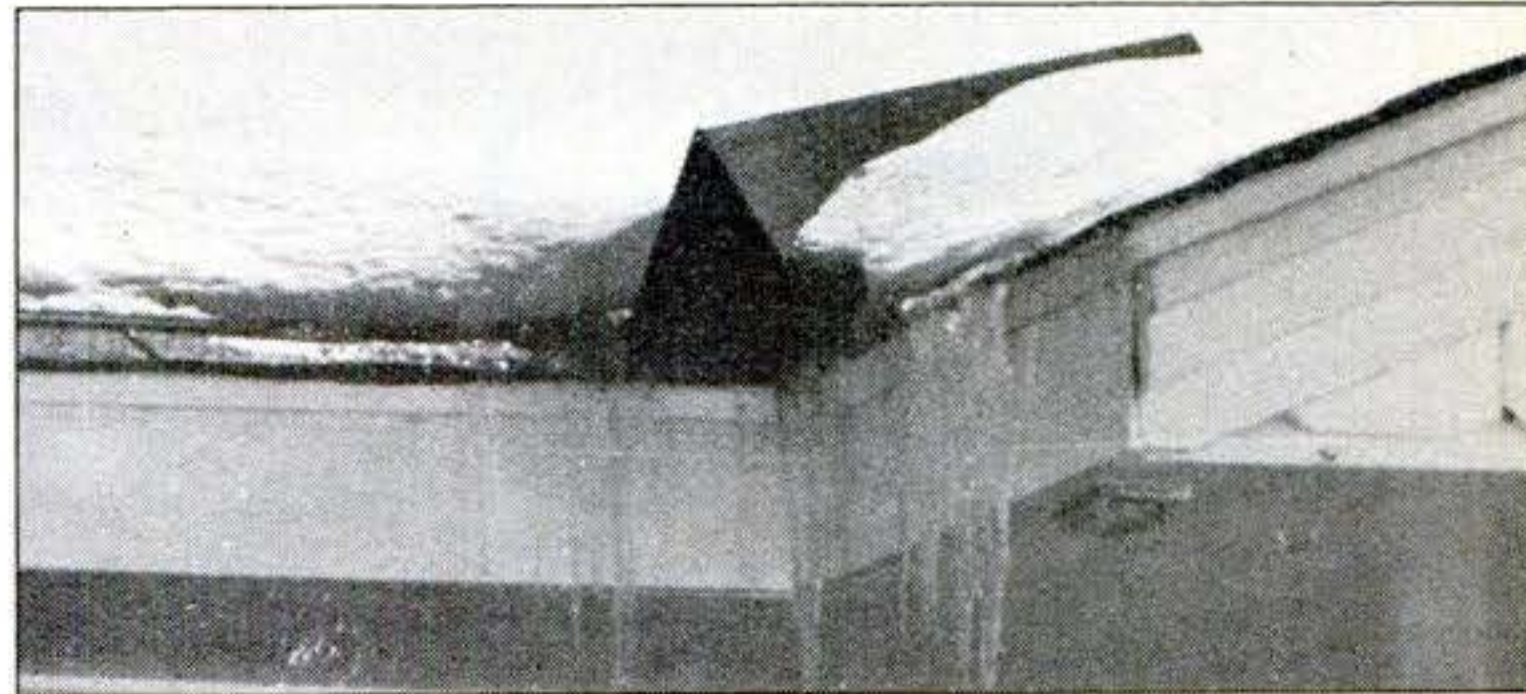


Shelf maker

You can create custom shelves without carpentry skills, using the Sisu Shelf Bracket. It attaches with two screws to wood uprights and supports any 3/4-in.-thick shelf. A set of four costs \$2.39. Sisu Shelving, Box 8366, Fort Collins, Colo. 80525.

Ice melter

Let the sun prevent ice dams on your roof. Solar Thaw warms the roof beneath it, providing a runoff channel for melting snow. The triangular, insulated solar collector mounts in clamps sandwiched between shingles. Future Tech, Box 268, Mankato, Minn. 56001; \$30.



Fan cap

Whirling in the winter wind, a rooftop turbine exhausts attic air. Pop on the molded-plastic Turbine Toga to keep heat in while letting moisture escape. It's designed to withstand high winds, says American Turbine Covers (433 Walker St., Holly Hill, Fla. 32017). \$15.



Fiberglass filler

Stanley Hardware's Multiuse Fiberglass insulation is a four-ft.-long strip of one-in.-thick, one-ft.-wide fiberglass. Stuff it into cracks around air conditioners, plug up holes around pipes, and fill other irregular gaps. It costs \$2.59 per package.



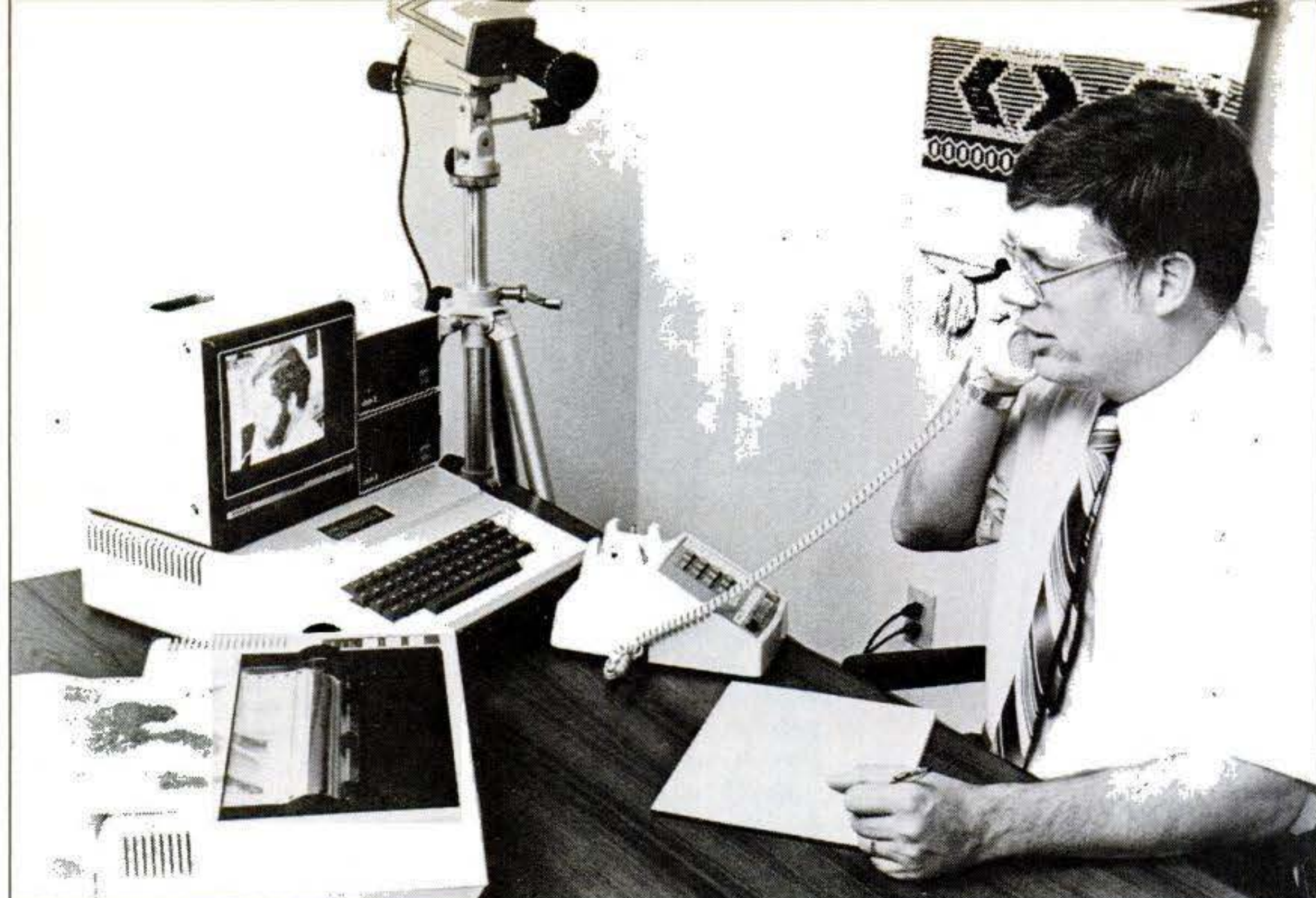
What's New IN ELECTRONICS

BY WILLIAM J. HAWKINS



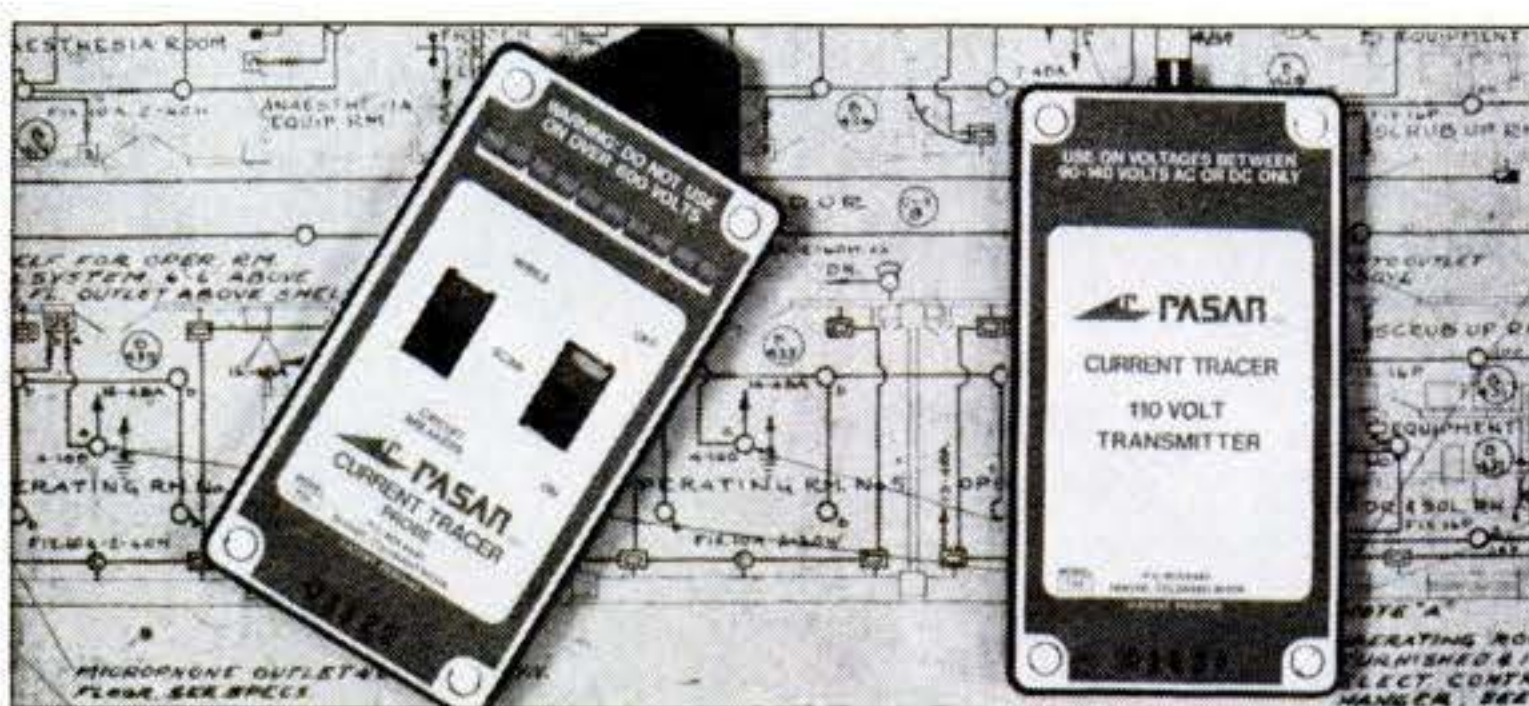
Micro timer

Just a simple timer? Yes, and thanks to a built-in microprocessor, it's probably the easiest you'll ever use. Tap the buttons and you instantly program on-off times for any appliance plugged into it. Made by Intermatic, Spring Grove, Ill. 60081, it's \$50.



Computer pix

Aim the camera; push a button. PhotoCaster, from Commsoft (665 Maybell Ave., Palo Alto, Calif. 94306), converts the image to bits and bytes for disc storage or sending through a modem. Circuit board, software, and camera are \$750. \$500 buys the board only.



Tummy power

To keep videotaping for up to 12 hours, all you need is a good belt . . . around your waist. The Power Belt, made by VDO-Pak (Box 67, Port Orange, Fla. 32019), holds enough 12-volt rechargeable batteries to provide up to 17 amp-hours for your VCR, camera, and lights. It's \$300.

Circuit finder

The transmitter goes at one end of an AC line; the tracer box lets you find the line as it weaves through walls. With power on or off, the clever system lets you trace just one wire in a wall of many. Made by Pasar (Box 6485, Denver, Colo. 80206), it's \$369.



Big stick

Tools of the trade: The aliens have their photon torpedoes, but now you can have the Point Master Competition joy stick by Discwasher. Made for Atari video games, its long handle means easier handling; the top-mounted button means faster response. Made for humans only, it's \$17.



Bedside center

Overslept? Then you need this Uniden AM/FM clock radio. If the alarm doesn't wake you, the boss will when he calls: The EX 7000 also contains a built-in wireless phone that works up to 50 ft. away. You may lose your job, but you'll end bedside clutter. It's \$220.

Tape-TV-cooker

It's been a big problem: What do you do while your dinner is cooking in the microwave? If you're using this new Sears cooker, there's an answer: For quick meals, you play its built-in stereo cassette deck. And for longer cooking times, you switch on its TV set. \$1,500.



What's New FOR YOUR CAR

BY JACK KEEBLER



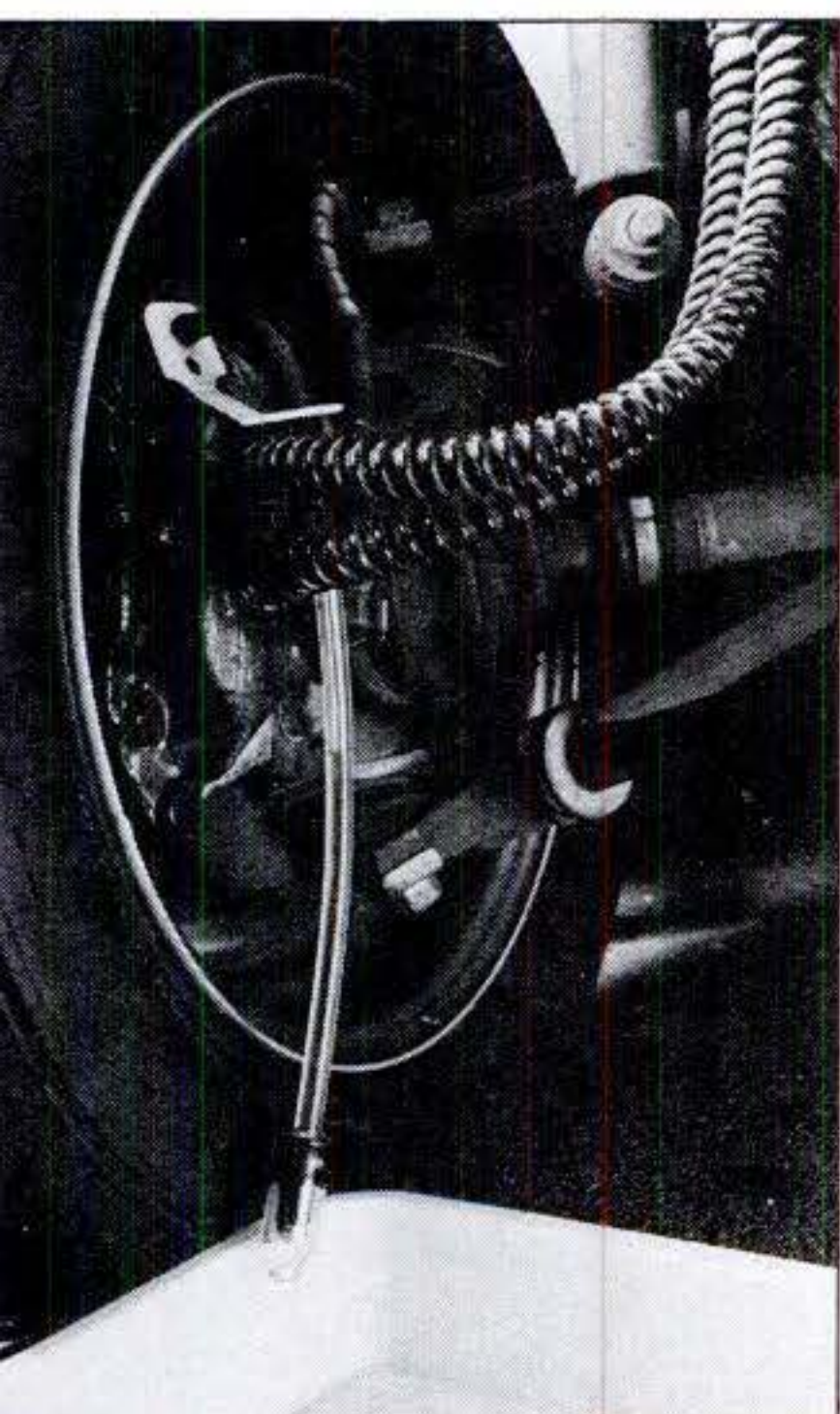
Recharger

Don't mess with jumper cables: Insert one end of Easy Charge's 16-foot cable into your car's lighter and the other into the lighter of the car in distress. Five minutes later, claims Unique Products (340 Poplar St., Hanover, Pa. 17331), you can restart. It costs \$22.90.



Powerful polisher

Make quick work of waxing and polishing your car with Black & Decker's 3/4-hp random-orbit polisher. Random-orbit polishing simulates the motions of hand polishing and won't burn the paint, says B&D. A two-speed locking switch controls the polishing action. Price: \$62.58.



Brake-bleed aid

Vizibleed makes bleeding your brakes easy and mess-free, claims Lucas Girling (Birmingham Rd., West Bromwich B71 4JR, England). The transparent tube, held in place by a clamping collar, won't pop off no matter how hard you press the pedal, says the maker.

Diesel timer

Luminosity Diesel Timer reads engine rpm and timing degrees on diesel cars and light trucks, says OTC Tools & Equipment (927 Eisenhower Dr., Owatonna, Minn. 55060). A fluorescent display enables you to read and adjust timing for maximum performance. \$499.



Tiny console

No space in your car's dash for extra gauges? A Mini Console from VDO Instruments, Inc. (980 Brooke Rd., Winchester, Va. 22601), may be the answer. Housings are available for one, two, and three gauges. They cost \$5.45, \$7.25, and \$10.75.



Keyless car door

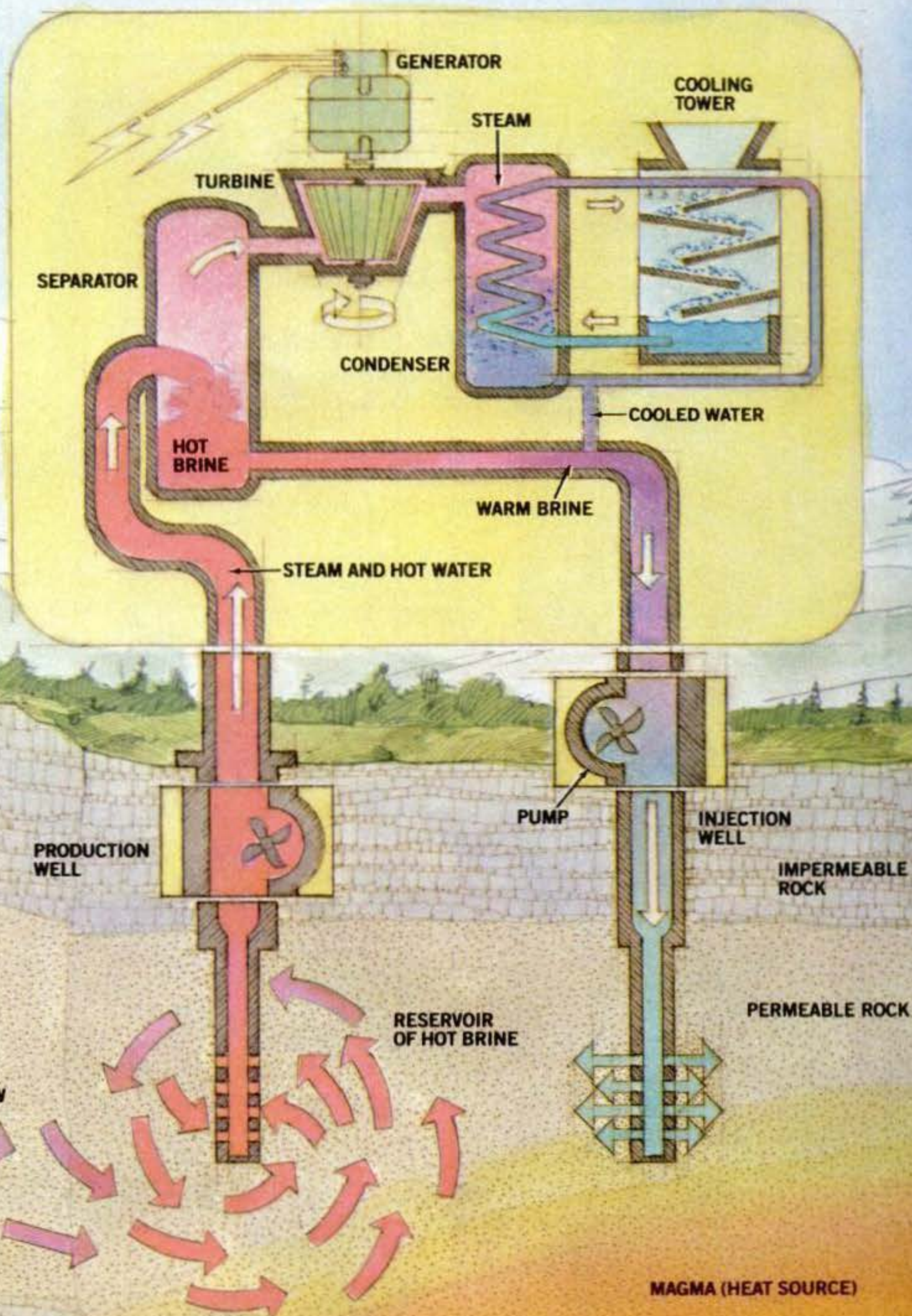
Press the key fob's button and your car's doors unlock by remote control. The device, developed by Neiman in France, is part of an optional infrared locking system in the new AMC-built Renault Alliance. It eliminates fumbling for keys in the dark and frozen door locks. \$72.

Hot-water power

from the earth

Energy from the earth starts as ground water that drips down through faults in the impermeable rock. Heated by molten magma, the water rises, gets as hot as 600 degrees F, but does not boil because it is under tremendous pressure. When pumped to the surface (right) the pressure is reduced, and part of the water flashes into steam that drives an electric generator. The leftover brine and condensed steam are reinjected back into the earth.

DIRECT FLASH



New technology brings this most abundant of geothermal sources closer to commercial reality

By **TOM JOHNSON**

ILLUSTRATION BY BARRY ROSS

Rancher Boyd Christensen reached down to open the faucet connected directly to his well pipe. "Better not put your hand under it," he told me. The water gushed out with a blast of steam.

"That's coming straight out of the ground at between 209 and 212 degrees Fahrenheit," he said. "It's so pure that the women working here in the greenhouse make coffee with it straight from the tap."

Christensen isn't interested in making coffee in the high mountains of Southwest Utah—he's interested in cutting his utility bills. That's just what the water, heated by natural hot rock less than 500 feet below his boots, does for him.

Four 3,600-sq.-ft. greenhouses on the Christensen ranch originally were heated by natural gas.

"I was paying about \$2,400 a month to the utility company," he said. "Since we installed the hot-water system, the bills have averaged about \$40 a month."

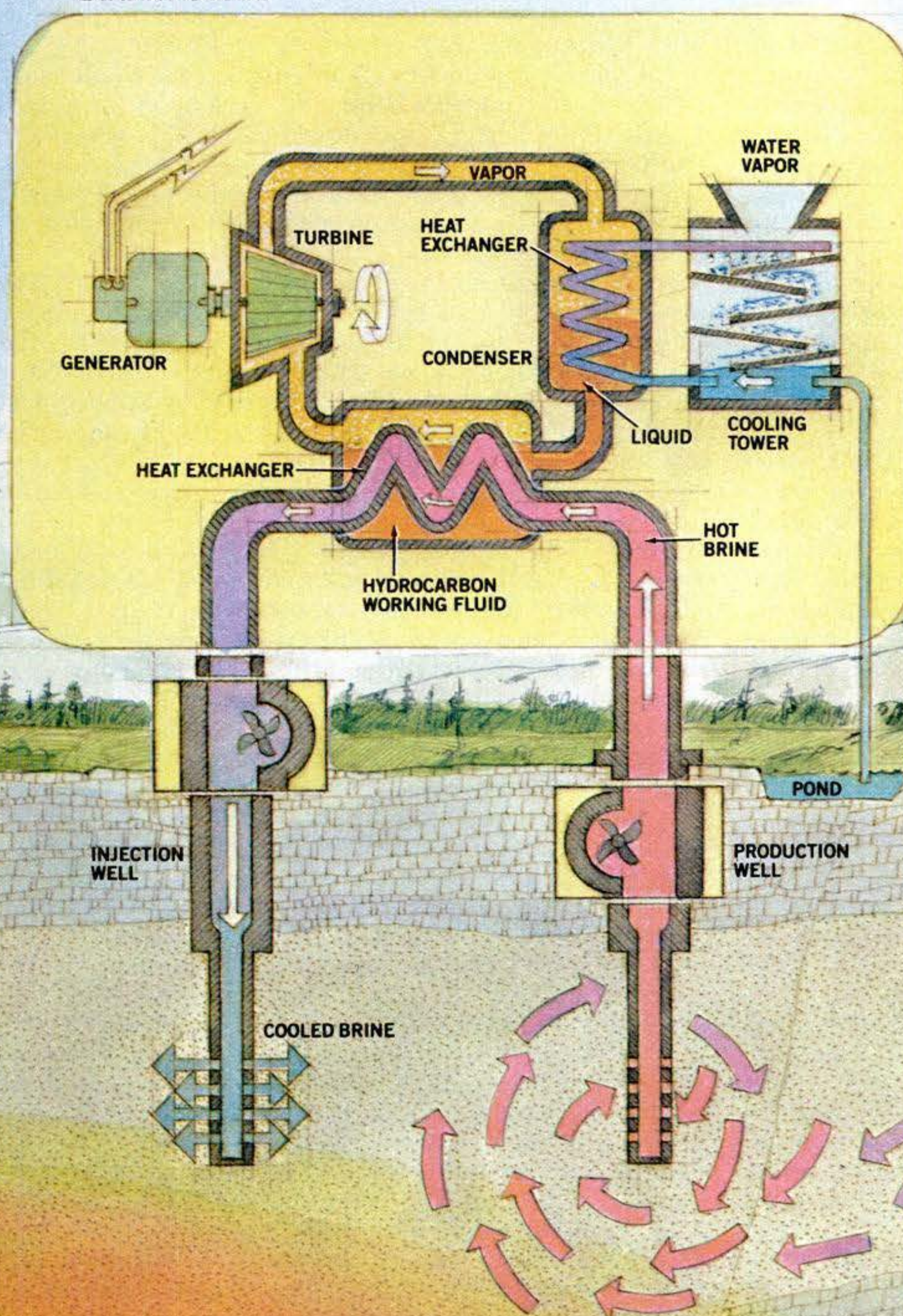
With such success stories, it may seem that geothermal energy is an economic panacea—heat energy from the earth that's free for the taking. And for some fortunate Westerners, it is. Boise, Idaho is still using hot-water wells drilled in 1890. And down-hole heat exchangers in hot-water wells have been used in Klamath Falls, Idaho since the early 1930's.

Like the Christensen ranch, these towns sit squarely atop geothermal fields. Most areas aren't so lucky. So the only practical way to harness the vast energy stored in the earth is by feeding it into the nation's electrical grid.

For the past 10 years, engineering teams around the nation have been working on converting geothermal energy into usable electricity [PS, Aug. '72, Nov. '74, Feb. '79, Jan. '82]. Recently, I visited geothermal sites throughout

Continued

BINARY CYCLE



In the binary system the geothermal fluid does not flash to steam. Instead, the brine flows through a heat exchanger immersed in a working fluid (mainly isobutane). This vaporizes, expands, and emerges from the tank at very high pressure, driving the turbine. The leftover vapor travels to the condenser, where it's cooled and recycled. Meanwhile, the brine is recirculated back to the earth, to be reheated for future generations.

Barry Ross

the West to discover what concrete progress has been made to put into practice the research of a decade.

"The big research question is not whether you can run a turbine with geothermal steam," Dr. Ian Straughan, manager of geoscience systems for Southern California Edison, told me. "We can do that. But what materials are necessary? What maintenance do various sections of the plant require? And what's the cost of it all? Those are the factors that will determine if geothermal power is economical."

Hot-water power will be economical, most experts agree, when two engineering problems are solved: how to extract maximum energy from a geothermal deposit; and how to control clogging and corrosion caused by minerals dissolved in the hot fluid.

The ideal geothermal field is hot enough to deliver "dry" steam (no liquid in the geothermal fluid) directly to a turbine generator. Such is the case at The Geysers, the world's largest geothermal electrical facility [PS, Aug. '72]. There, a plant operated by Pacific Gas and Electric Co. and Union Oil is producing 910 megawatts of electricity, enough to meet the needs of San Francisco 90 miles to the south.

But only about 0.5 percent of the earth's geothermal reserve can be brought to the surface as dry steam. More commonly, the resource arrives at the wellhead as hot water of varying temperatures. How that fluid is used depends on its temperature and mineral content.

While Boyd Christensen's brine is pure enough for coffee, most geothermal fluids are "dirty." Some carry as much as 35 percent total dissolved solids. These minerals in solution are a devilment to the hardware in a geothermal power plant. Unless the engineering and construction methods are just right, a three-inch pipe carrying geothermal brine can be choked to a half-inch-diameter flow in 100 hours of operation. Controlling this mineral buildup, or scaling, has been the major challenge for engineers at the first two U.S. hot-water power plants.

Hot valley

Four hundred air miles southwest of the Christensen ranch is possibly the largest geothermal resource in the nation—California's fertile Imperial Valley. The valley surface is flat as a bedspread. But it covers a mattress made thermally lumpy by geologic activity boosting temperatures in layers of porous rock deep underground. Six known geothermal resource areas have been identified there, with thermal fluids ranging from 240 to 660 degrees F. The geothermal fields are between 2,000 and 10,000 feet below the surface.

Near the valley's Salton Sea, three demonstration generating plants are each producing between 10 and 14 MW of power—enough to power a town of 6,000. Two more are in early stages of construction, including a 50-MW commercial plant.

Union Oil Co. has been delivering steam to Southern California Edison's 10-MW demonstration plant at Brawley since June 1980. This is the first U.S. pilot plant to generate power using the direct-flash method.

At Brawley, high-temperature water (above 410 degrees F) is drawn from wells tapping the subterranean reservoir. The fluids are pumped to the surface under pressure and routed through a series of vessels. This reduces the pressure, causing some of the liquid to "flash boil," or vaporize, just as it does when you take the lid off a pot of boiling water. The steam, about 20 percent of the fluid, is fed through a standard steam turbine. The rest of the brine is pumped back underground through injection wells. One thing the engineers have learned: The Brawley field's geothermal fluid, with 15 percent total dissolved solids, is a lot harder to deal with than first thought.

"The original concept was to keep everything in solution by maintaining a high pressure and a high temperature," SoCal's Straughan told me in his office near Los Angeles. "But problems come after flashing off the steam; the temperature of the brine drops and the solids precipitate out of solution. These solids were plugging up the injection wells. And if you have to reduce the rate of discharge you also have to reduce the rate of inflow," he said. "That slowed down steam production."

At Brawley, the solution was to discharge the fluid in cooling ponds and let the minerals and salts drop out of solution. After the fluid cools, the liquid can be injected and the minerals hauled away.

A more elegant fix was devised for a second 10-MW direct-flash plant that started up on July 4, 1982. When I visited that plant on the shore of the Salton Sea, it had been running continuously for nearly 60 days, and everyone in the industry was keeping his fingers crossed. According to Straughan, the plant was working well because Union Oil engineers had devised a new way to control clogging. They inserted a closed crystallization system in the fluid line that pulls off a mineral concentrate before the brine reaches the flash point. "The concentrate passes through filter presses and the mineral 'cake' is carried off before it reaches the flash vessels, turbine, or injection wells," Straughan said.

"Of course, that doesn't eliminate all of the challenges," he added, moving from behind his desk to pick up what looked like a rusty French-bread pan. "This was a 410 stainless-steel vane from a moisture separator on our generation side of the plant." A year's operation left the 15-by-four-inch strip a collection of holes held together by red-black rust.

SoCal Edison seems ready to meet those challenges. The power company also has Chevron Resources Company drilling production and injection wells at a site in the Heber geothermal field, about 20 miles south of Brawley and a stone's throw from the Mexican border. A 52-MW, double-flash demonstration plant is expected to be running by mid-1984.

"The Heber plant uses a different technology, because a lower-salinity brine is available compared with that at Brawley or Salton Sea," said George Crane, a SoCal engineer. "The first flash vessel will take the 360-degree-F fluid and split it—five to 10 percent steam and the rest liquid. That steam, at about 60 pounds per square inch, goes to the high-pressure part of the turbine. The brine goes on to a second phase, where the steam comes out at about 16 psi and into the low-pressure part of the turbine."

Engineers at SoCal Edison are confident that the \$70 million plant at Heber will work because the technology they will be using is, essentially, off-the-shelf. A similar double-flash plant has operated successfully in Japan.

But just a mile away from the Chevron-SoCal Edison site, construction began this past fall on a demonstration plant that will be the world's first commercial-scale facility using binary-cycle technology. In this system, the hot water doesn't flash to steam but heats a working fluid that drives the turbine.

"We think the advantage of this technology is that it will minimize—we hope, eliminate—problems of brine composition and of varying temperatures," Robert Lacy, head of the \$122 million project for San Diego Gas and Electric, told me in his office overlooking the San Diego harbor.

At the Heber binary-cycle plant, the 360-degree-F brine at 250 psi flows to a heat exchanger (see illustration), where it surrenders its heat to a hydrocarbon fluid that's 90 percent isobutane and 10 percent isopentane. The fluid has a very low boiling point. When vaporized at these high

temperatures, it expands tremendously and reaches a pressure of 575 psi when it reaches the turbine.

The brine, though cooled to 154 degrees, remains under pressure. "We think that by keeping the brine under pressure all the way through the system we can avoid scaling and problems with noncondensable gases," Lacy said.

The pressurized brine is pumped to an injection island 2½ miles away on the edge of the Heber geothermal reservoir. It is thought that once the brine is returned to the strata, it will be geologically reheated and available for power generation years hence.

Tricky technology

"There are three areas in the Heber binary project that are going to be tough," Lacy noted. "One, there has never been a 70-megawatt hydrocarbon turbine used before. Two, when that brine is under pressure it is a 'solid,' in physics terms; thus the controls can be very tricky. Three, down-hole pumps will be used to bring brine up and keep it under pressure; they need to be perfected."

One thing Lacy doesn't have to worry about is noxious odors—a common problem in developing geothermal fields. The presence of hydrogen sulfide and other noncondensable gases can foul the air for miles. Fortunately for the developers in the Imperial Valley, the brine there is unusually clean in this regard. I spent an afternoon going through the Salton Sea facility. The only time I got a whiff of the H₂S rotten-egg smell was when I was on the roof of the control building shooting pictures and practically stuck my nose in the air-conditioning exhaust.

“The sex appeal of the binary system is that it can give great efficiency with relatively low-temperature brine”

Although San Diego Gas and Electric's binary generating plant may be the largest constructed, it won't be the first. That honor, although sometimes a costly one, belongs to the Magma Power Co.—now Imperial Magma—test facility in the East Mesa geothermal field on the eastern flank of the valley. Magma first cranked up its binary plant in 1980, operating spasmodically but producing nearly 10 MW of power for as long as 90 days. That plant employs a low- to moderate-temperature brine with two different hydrocarbon working fluids passing through heat exchangers.

Magma President Tom Hinrichs was up to his hard hat in a major plant refitting when he took time to show me through the facility. Originally, the power station was using a uniquely designed shell and tube heat exchanger to transfer the brine's heat.

"By the fall of '81, the shell and tubes had corroded so much that they got leaky," he told me, "and the turbine was leaking lubricating oil, as well. At the high temperatures, that oil also became a corrosive."

Dow Chemical Company, which has considerable experience in dealing with corrosive materials, was called in to re-engineer the plant. "We're now just finishing up a \$5 million retrofit," Hinrichs said. "The turbines, with an external lubricating system, have been installed, along with new heat exchangers with thicker tube walls."

The heat from the East Mesa brine will be taken off in two stages. The first will take the 350-degree-F brine to vaporize isobutane. That vapor will be channeled to a 12-

MW turbine. Then the cooler brine—240 degrees F—will move on to a second-stage heat exchanger that will vaporize propane. That steam will spin a two-MW turbine.

"It takes about 25 percent of our generating capacity to run the plant," Hinrichs said, "but we've got a system showing that power can be generated with 240-degree water. The sex appeal of the binary system is that it can give great efficiency with relatively low-temperature brine."

That could be important even for high-temperature geothermal fields. To be economical, most fields must produce for 30 to 35 years. But geothermal engineers and geologists expect that the brine temperature will drop somewhat over time. San Diego's Robert Lacy thinks substituting working fluids with lower boiling points will let engineers extract energy from the fluids even as the brine temperature drops.

For all its potential efficiency, the binary cycle still uses geothermal heat indirectly—so some is lost. And the direct-flash system uses even less of the heat energy available in the brine—only that which flashes as steam. The remaining hot water does no work.

But back north, just 30 miles across the sage and tumbleweed from the Christensen ranch, encouraging tests are under way to harness that wasted hydro-energy.

Last January, *POPULAR SCIENCE* reported on a planned test of a rotary-separator turbine, sometimes called a bi-phase turbine. According to Lynn Rasband, manager of advanced development for Utah Power and Light Co., the test succeeded.

"We installed the rotary-separator in only five weeks in the fall of 1981," Rasband told me as we stood in the chill afternoon winds of the high desert last April. "Two weeks later, the turbine generator was synchronized with the UP&L grid and 1.6 megawatts of power was flowing to our customers."

With the new turbine, the steamy geothermal liquid is pumped through a nozzle, lowering the pressure as it exits, thus producing more steam and giving kinetic energy to the water. At that point the water is captured in a rotating drum, where it is separated from the steam by centrifugal force. The vapor is tapped off and sent to a normal steam turbine. The water is channeled to a special liquid turbine, which spins like an enclosed water wheel to produce yet more electricity. Its energy spent, the water—along with the condensed steam—is injected back into the rock.

After running continuously for 10 weeks, the test unit was shut down for equipment adjustments and piping changes on the wells. But all systems were go by late August, and the unit was started up again for a six-month endurance test. Even while the 1.6-MW unit is being tested, construction is going ahead on a planned 20-MW generating plant that is expected to be pumping out current by the spring of 1984.

"The turbines and pumps have been purchased, the site preparation is done, and tests are under way on the injection wells," Rasband said. "We plan to run the 20-megawatt plant for a one-year test. If that pays off as we hope, we'll be building three 50-megawatt plants by 1990."

This construction schedule is an example of another reason why geothermal generating plants may prove practical. "Geothermal plants can get on line fairly quickly—from initial planning to generation in three to 3½ years," said San Diego's Robert Lacy. "That schedule is attractive to resource planners, and you're not tying up all your development money in long-term interest payments."

We can expect to hear more about even larger geothermal projects in the West. Commented Lacy: "It's unlikely we can build more nuclear plants; oil and coal are too dirty; and gas is becoming too expensive."

Solar add-on

—buried pipes stabilize temperatures

Air flows through a thermal mass to heat or cool this sun room

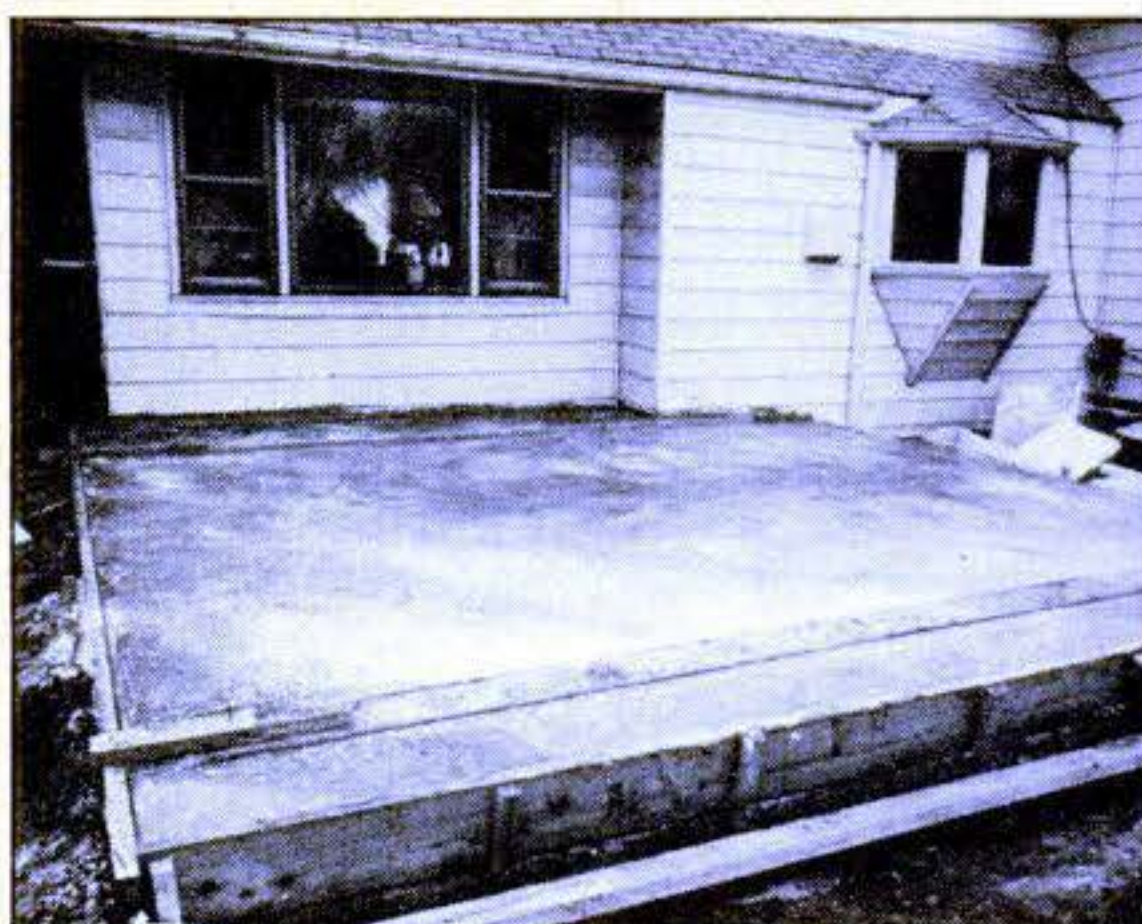
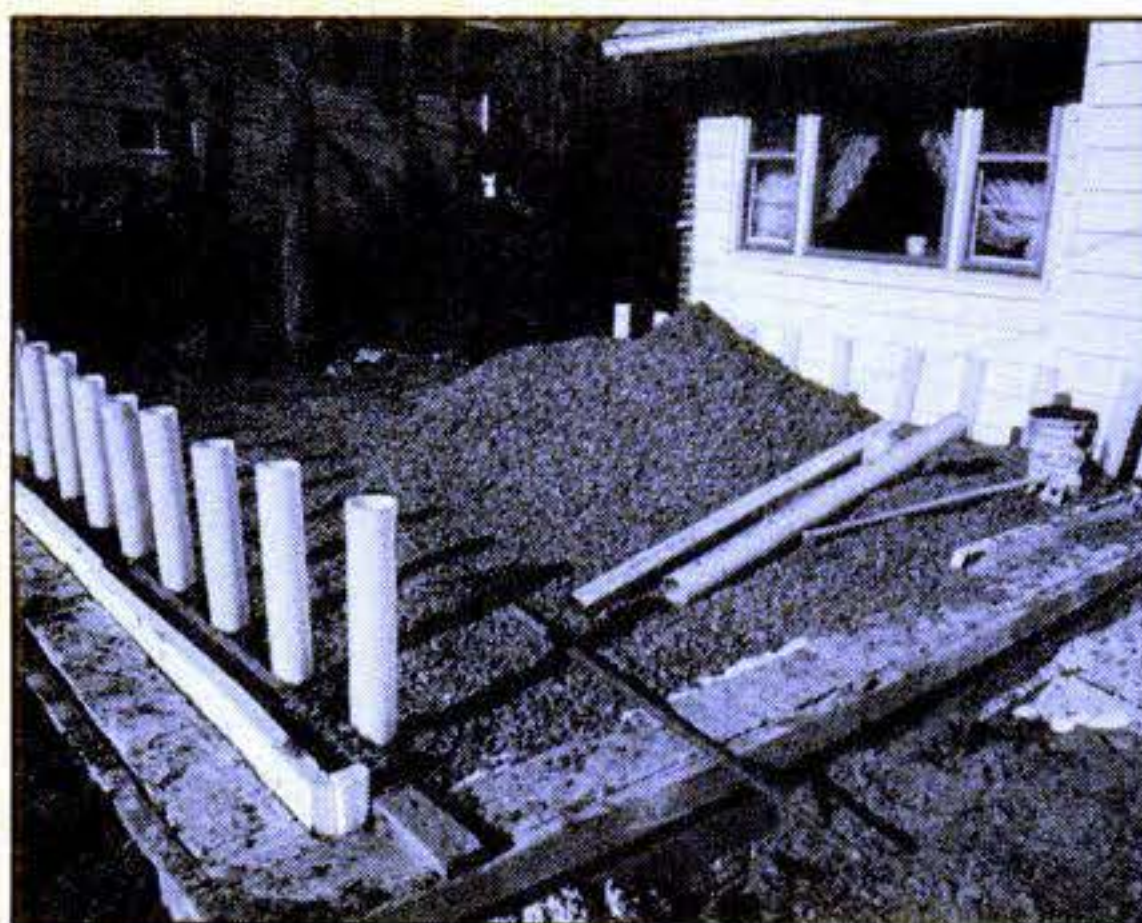
By **ARTHUR FLATHERS**

ILLUSTRATIONS BY CARL DE GROOTE

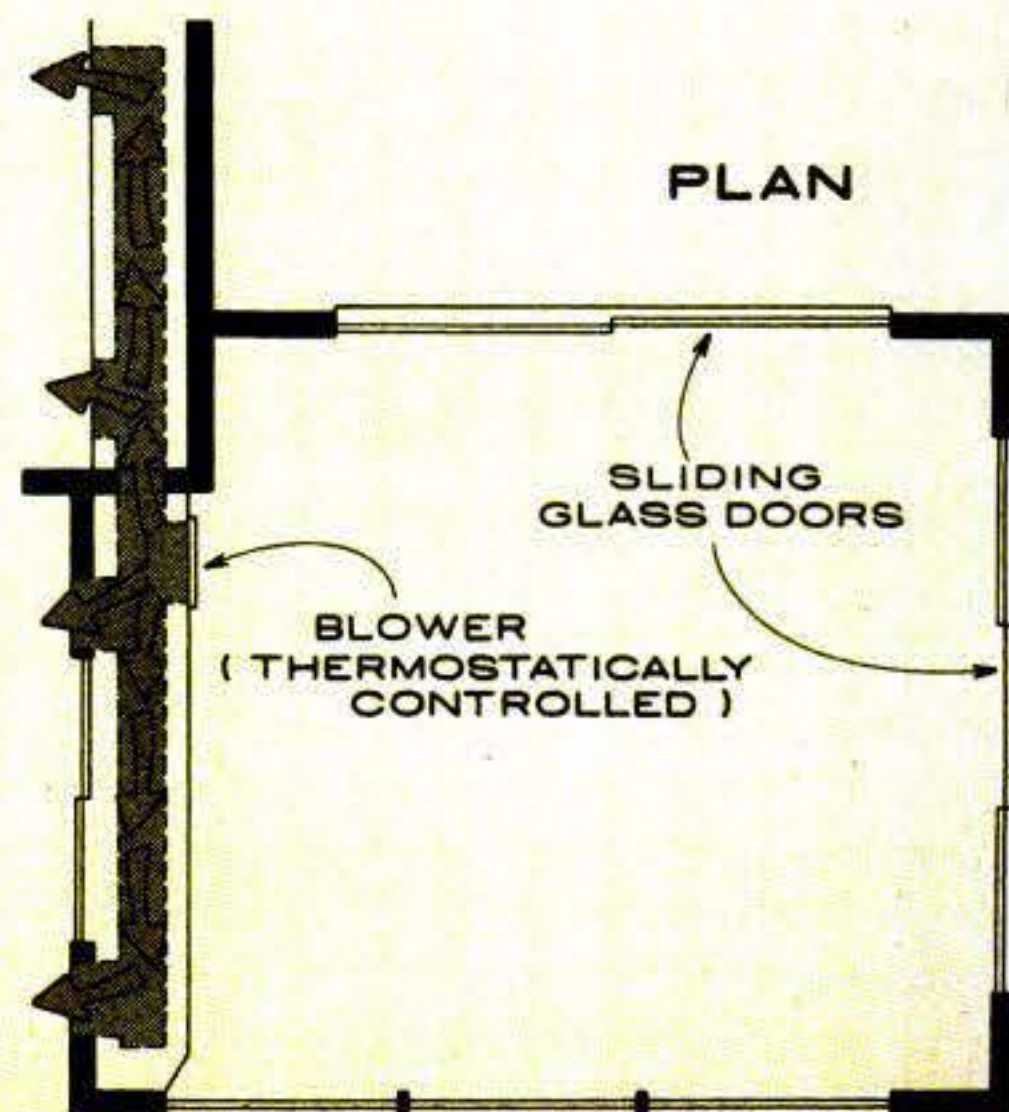
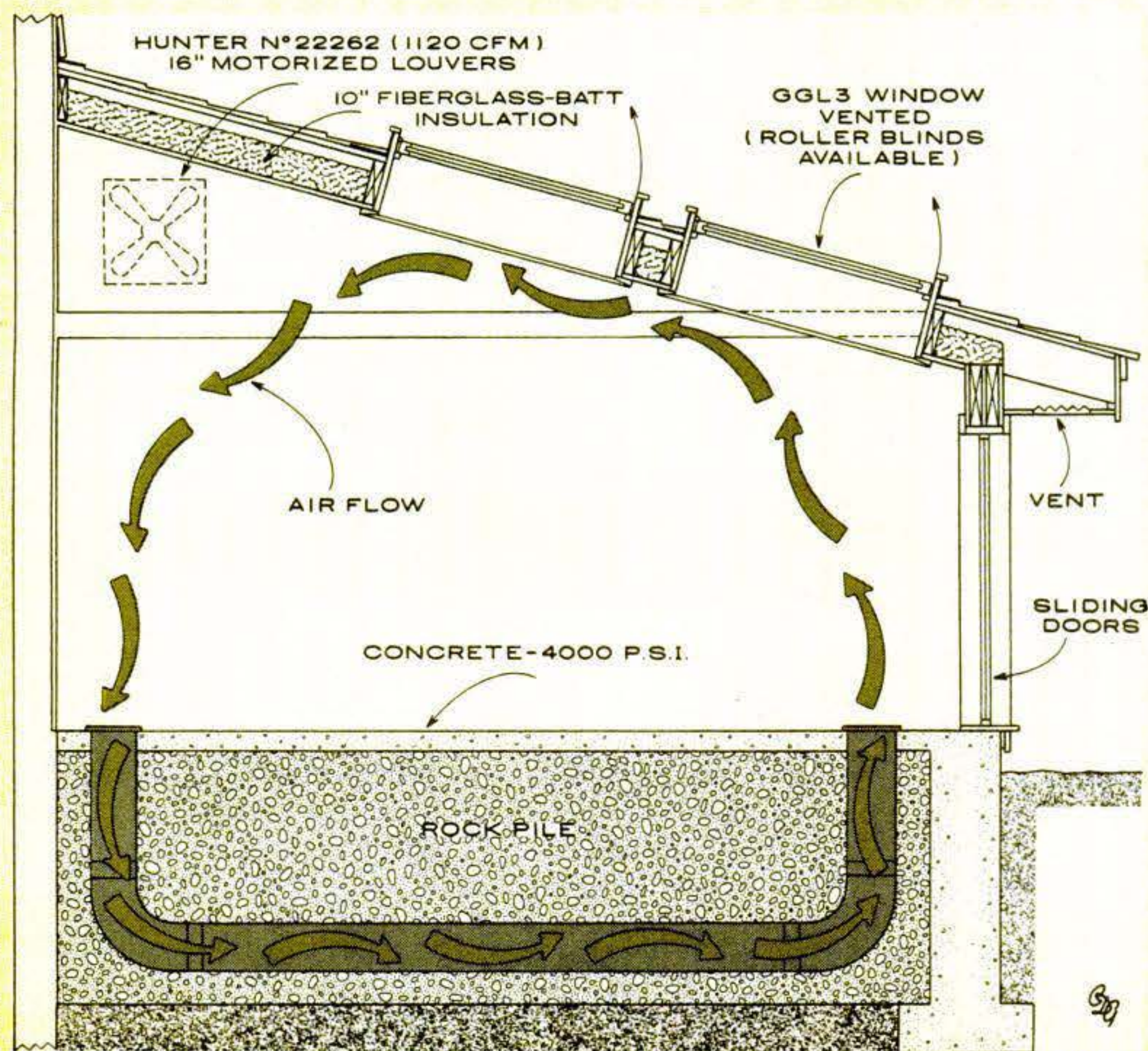
Hot and cold—too much of either can make an add-on solarium uncomfortable through the summer and winter months. To stabilize the temperature year-round, this design uses the floor as a 70-ton thermal mass and PVC pipes for thorough air circulation.

Four-inch-diameter pipes are buried beneath the six-foot-deep rock mass and extend up to floor grilles at both ends of the room. Air passing through the pipes is heated or cooled by the mass.

Thermostatically controlled fans help circulate the air flow through the solarium and, during the winter months, into the house. Velux windows are used as skylights and may be opened for more air circulation during the summer months. When they are closed, a separate exhaust fan can be used.



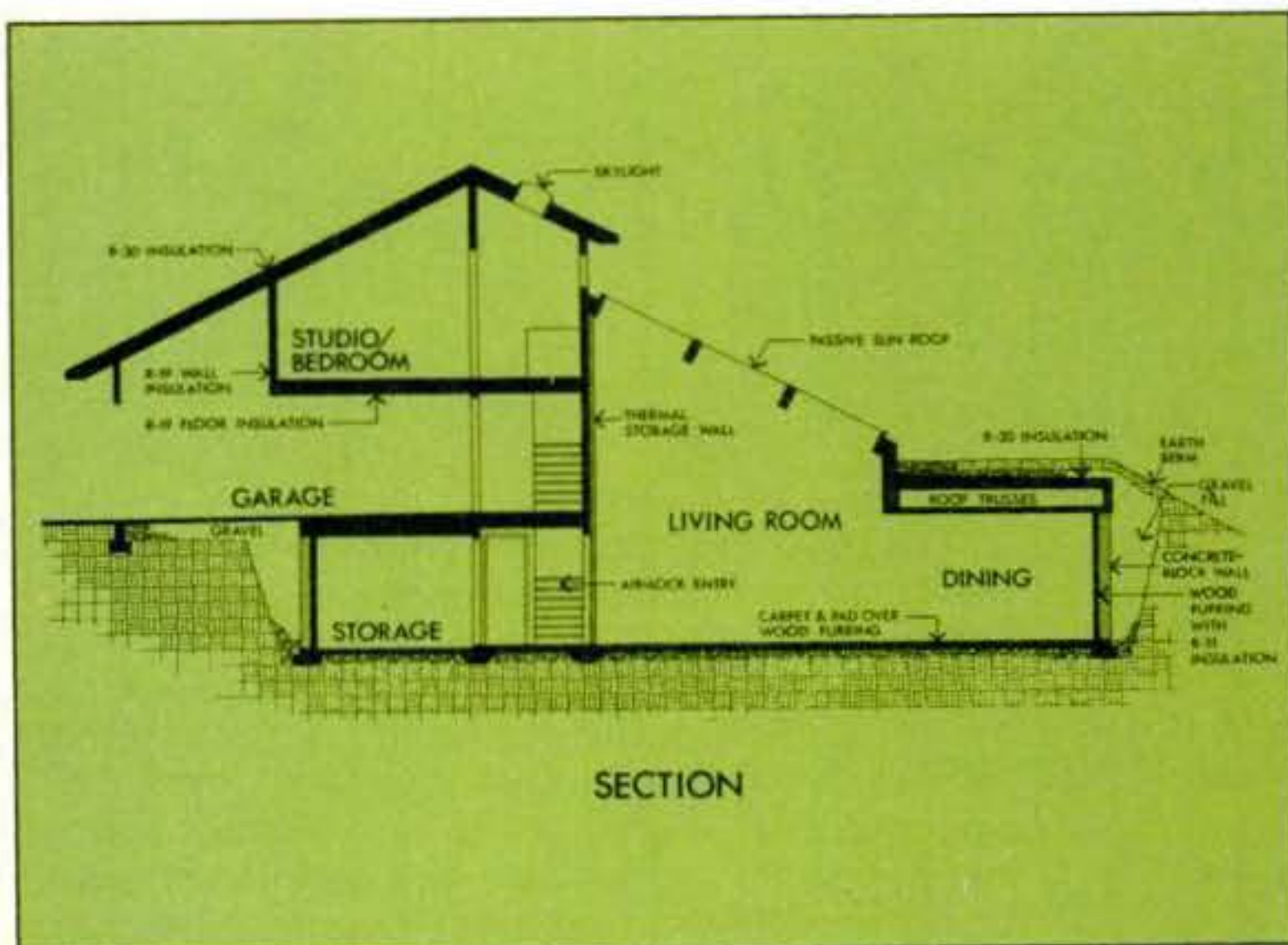
Poured-concrete footers, floor, and walls line the 15-by-18-foot bed. The four-inch PVC pipes are placed on 16-inch centers (10 pipes used here) and covered with about five feet of crushed stone. A four-inch reinforced-concrete slab floor, faced with ceramic tile, covers the bed.





South-southeast exposure provides sunlight to the solarium throughout the day in winter. A large maple tree on the southwest furnishes shade in the afternoon hours during the summer. Proper air flow is secret of stabilized temperature year-round. Grilles in American-Olean Primitive Encore tile floor allow air to circulate through underground PVC pipes and rock bed. Thermostatically controlled fans, mounted in enclosed area under roof, help circulate the air through the room; an exhaust fan removes unwanted hot or cold air at extreme temperatures.

Earth-sheltered solar



Lowest level of house is partially excavated and fully bermed, but is bathed in natural light by means of skylight roof and adjacent sunken courtyard (seen in exterior rendering above and through glass wall of living room, right). Cozy dining alcove is tucked under sod, as shown in section above.



By AL LEES

From the driveway, no one could guess the drama—or the passive-solar capability—this house harbors. Imagine the surprise and delight of first-time visitors who pass through the front gate and down sheltered steps to the entry level. Ahead is a wonderfully private sunken courtyard, ideal for alfresco dining or entertaining. The house wraps around this space and—since the L-shaped lower floor is below grade or earth-bermed—the rooms take their light from this courtyard.

The adjacent two-story wing gives the house its conventional "curb appeal." Designed for us as part of a series of energy-efficient leisure homes by Ken Gephart of Home Building Plan Service (in cooperation with the Western Wood Products Assn.), this house could take its place in any suburban community, as well. Though 61 percent of the 1,512 square feet of living space is earth-sheltered, the only room that doesn't have a direct view to the outdoors is the dining room.

Today's popular "great room" concept is given an especially dynamic treatment here, with a soaring two-story brick wall behind the wood stove. The thermal mass of this wall—and the paved floor—stores heat from the sunlight that pours through the skylights. (Wondering about those floating ferns? They're *not* plastic dust-catchers; they're hung from pulleys that let you lower the pots for watering.) And check that handsome end wall and corner, paneled in rich, naturally finished cedar boards that are also used as trim for the adjacent plasterboard wall and skylight ceiling. Double glazing, of course, is used throughout, and insulated draperies can be pulled across the courtyard wall on winter evenings.

The air-lock front entry offers a guest closet, access to two storage areas (the larger one tucked under the double garage, as shown in the section), and stairs that lead to the second-floor suite above the garage. This space is one of the most attractive, and versatile, features of the house. Self-sufficient, with its own full bath and closets and direct access to the entry, the suite could serve as a studio apart-

ment, guest room, study, or office. Note also (on the lowest-level floor plan) two other amenities for guests: a half-bath off the hallway and a wet bar behind French doors to the right of the wood stove.

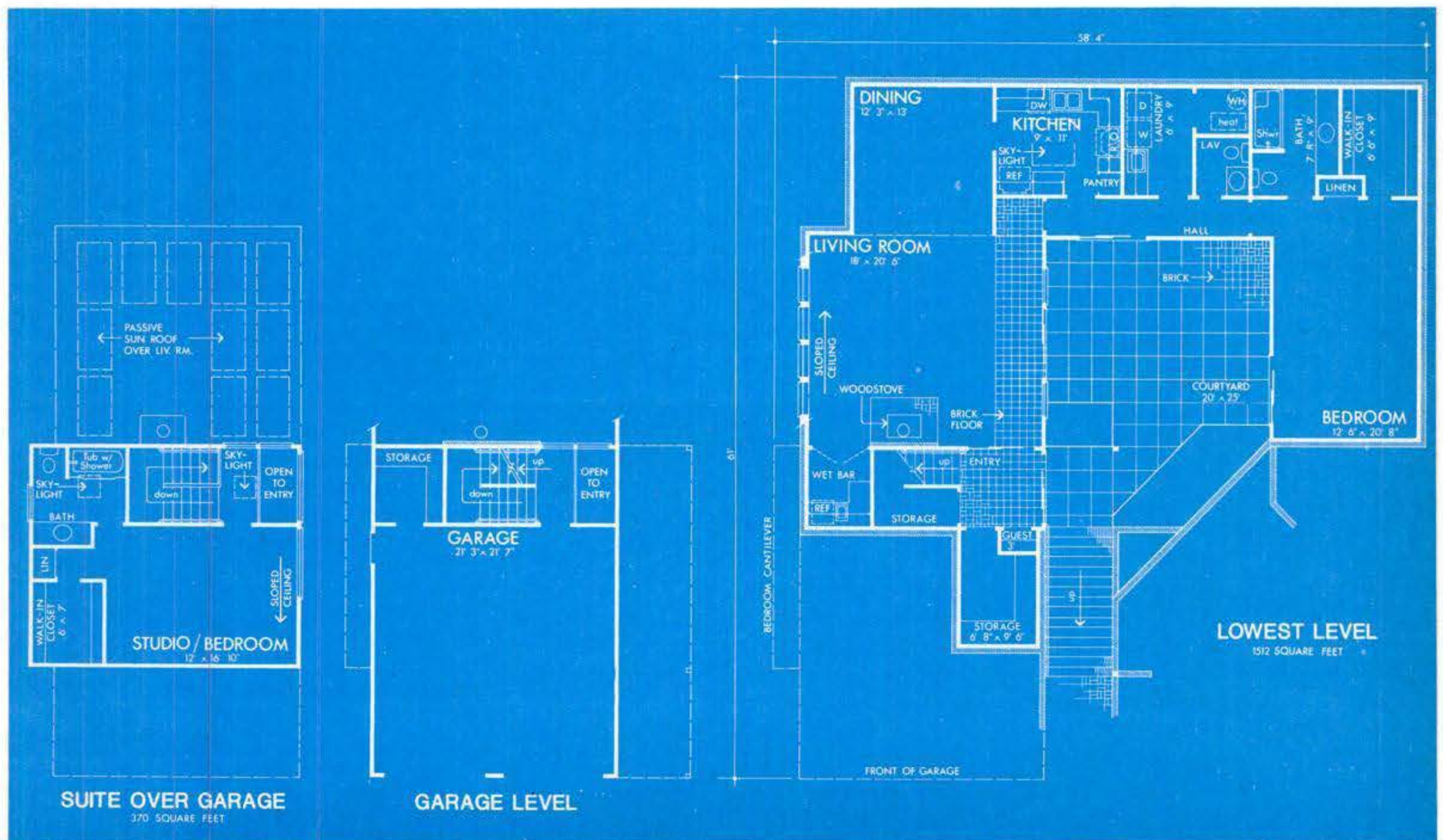
As with most underground homes, the sod cover can be pierced with skylights and vents—especially over kitchen and bath. For examples of the stepped-down retaining wall needed alongside the entry stair (not visible from the perspective of our rendering), see "Underground Basics" [PS, Nov. '82, pg. 77]. In good weather, the courtyard channels traffic flow through sliding glass doors to the living room, master bedroom, and kitchen hallway. In rain or snow, that hall provides a sheltered connection between rooms in the two wings.

All HBPS homes are designed to satisfy requirements of the Uniform Building Code. In addition to the double glazing, thick insulation is specified throughout for energy conservation. All construction materials are conventional, requiring no special skills.

If you'd like to compare this design with other HBPS homes we've commissioned, see last month's entry in this series, featuring a passive-solar wing to house a spa. Eleven other HBPS designs from earlier in this series are grouped under the chapter heading "Energy-Efficient Homes for the Do-It-Yourselfer" in the book *Leisure Homes*, available for \$18.95 from Popular Science Books, Box 2018, Latham, N.Y. 12111. PS

How to order your plans

One set of professionally drawn plans for this house is \$100; four sets (for building, financing, and filing for permits) are \$140. Specify plan number 954-1A. Mirror-reverse plan is available (specify how many in your order are to be reversed). Materials list is \$20; typical plumbing and wiring diagrams are \$7.50 each. Add \$5 postage to all orders. To use MasterCard or Visa accounts, call toll-free 1 (800) 547-5570 (this number for plans orders only). Or write: Home Building Plan Service, 2235 N.E. Sandy Blvd., Portland, Ore. 97232-2884.



Heat-saving vents

—are they the solution to indoor pollution?

Heat exchangers are said to provide clean air yet save heat. Do they? Are they good buys?

By V. ELAINE SMAY

DRAWINGS BY EUGENE THOMPSON

Last winter, the Colorado Energy Research Institute tested 30 relatively new, well-insulated homes and found that 18 had potentially unsafe levels of radon.

In Seattle, researchers studied more than 400 mobile homes and 200 regular homes with urea-formaldehyde-foam insulation and found high concentrations of formaldehyde in the air and an unusually high number of health complaints from occupants.

A recent U.S. General Accounting Office report says the air in homes may be two or three times more polluted than outside air.

And along with the proliferating reports of indoor pollution has come a proliferation of machines designed to rid our houses of it: air-to-air heat exchangers. These are forced-ventilation systems that blow warm, stale air from the house through a heat-transfer surface, where it gives up much of its heat to fresh, cold air being drawn in from outside. In summer, stale, cool air going out can pre-cool warm, fresh air coming in. The two air streams don't mix, so the pollutants travel out with the stale air. Air-to-air heat exchangers have been used in European and Japanese homes for years, but when PS first reported on them, in October 1980, there were only two for residential use available in the U.S. Now there are nearly two dozen.

The theory behind them: Really

tight houses built to be energy efficient are also efficient traps for contaminants. With their reduced infiltration rates, pollutants generated inside can't easily get out and may build up to unacceptable levels. The most common culprits: formaldehyde, nitrogen dioxide, radon, particulates, carbon monoxide, and excess humidity. Since low infiltration rates contributed to the problem, goes the theory, ventilation can solve it. And when you ventilate with an air-to-air heat exchanger, you blow out the stale air but recoup much of its heat—or coolness.

With all the flap about indoor air quality, you may be wondering about the air you breathe, especially if you live in a new house built to be ultra-tight or one that contains pollution-emitting products. Should you buy an air-to-air heat exchanger? Would it really clean up the air? Would it be cost-effective?

A good bit of research has been focused on these questions, and we know more than we did three years ago. But much more remains to be done. "We're still at the bottom of the learning curve on indoor air quality," says Dr. Gautam Dutt, research staff member at Princeton's Center for Energy and Environmental Studies. More on that later; first take a look at the machines.

Air-to-air exchangers

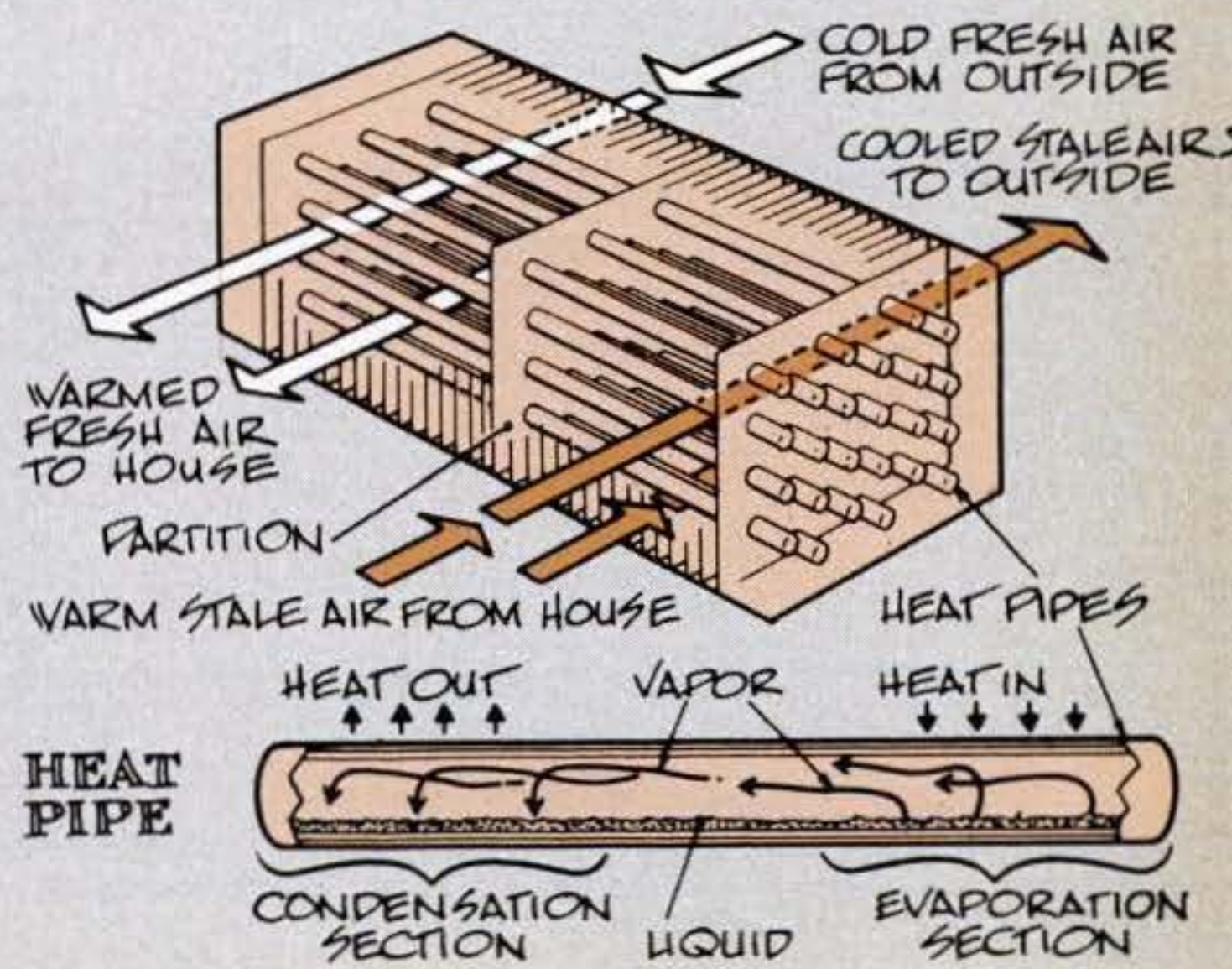
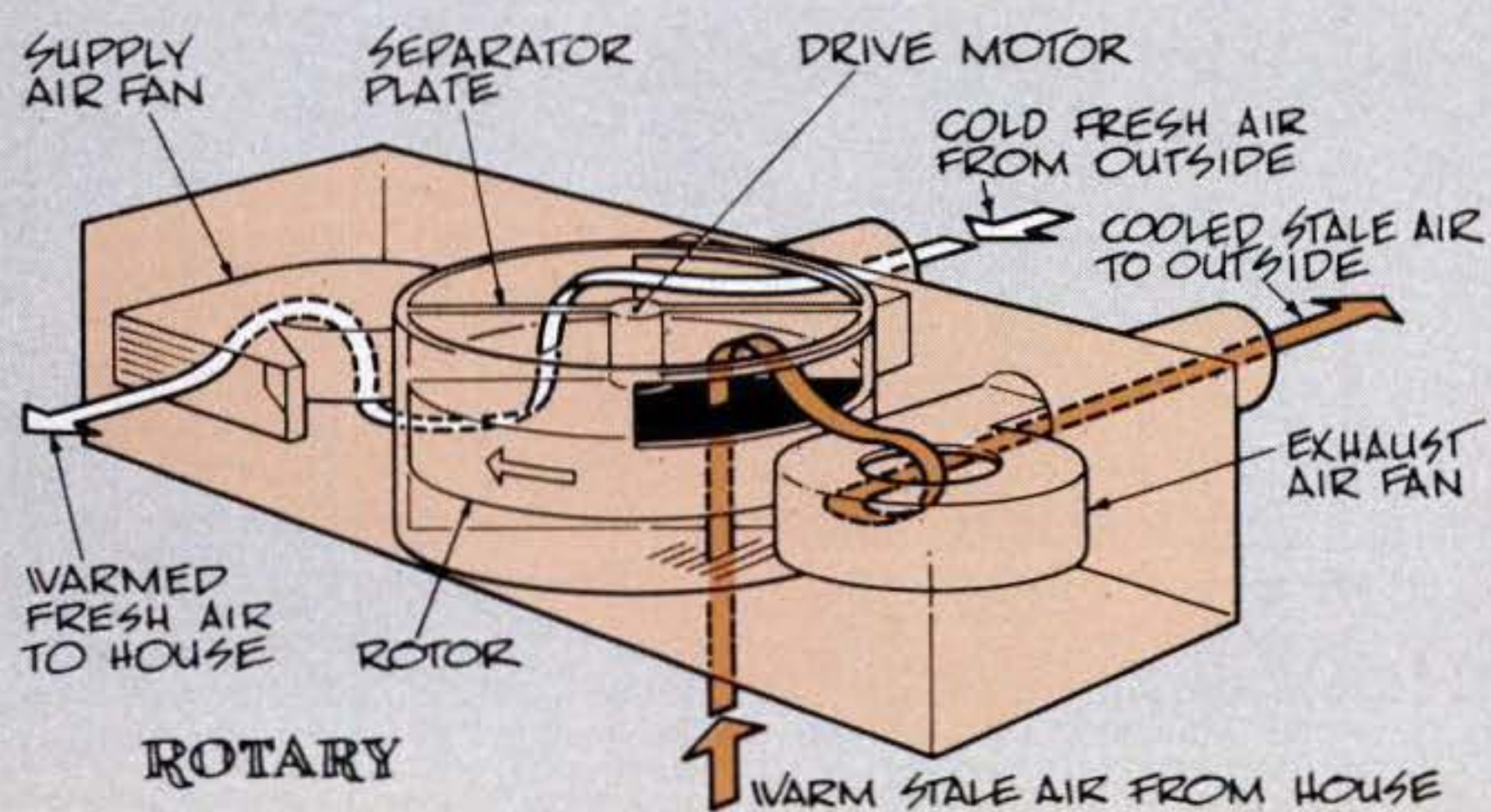
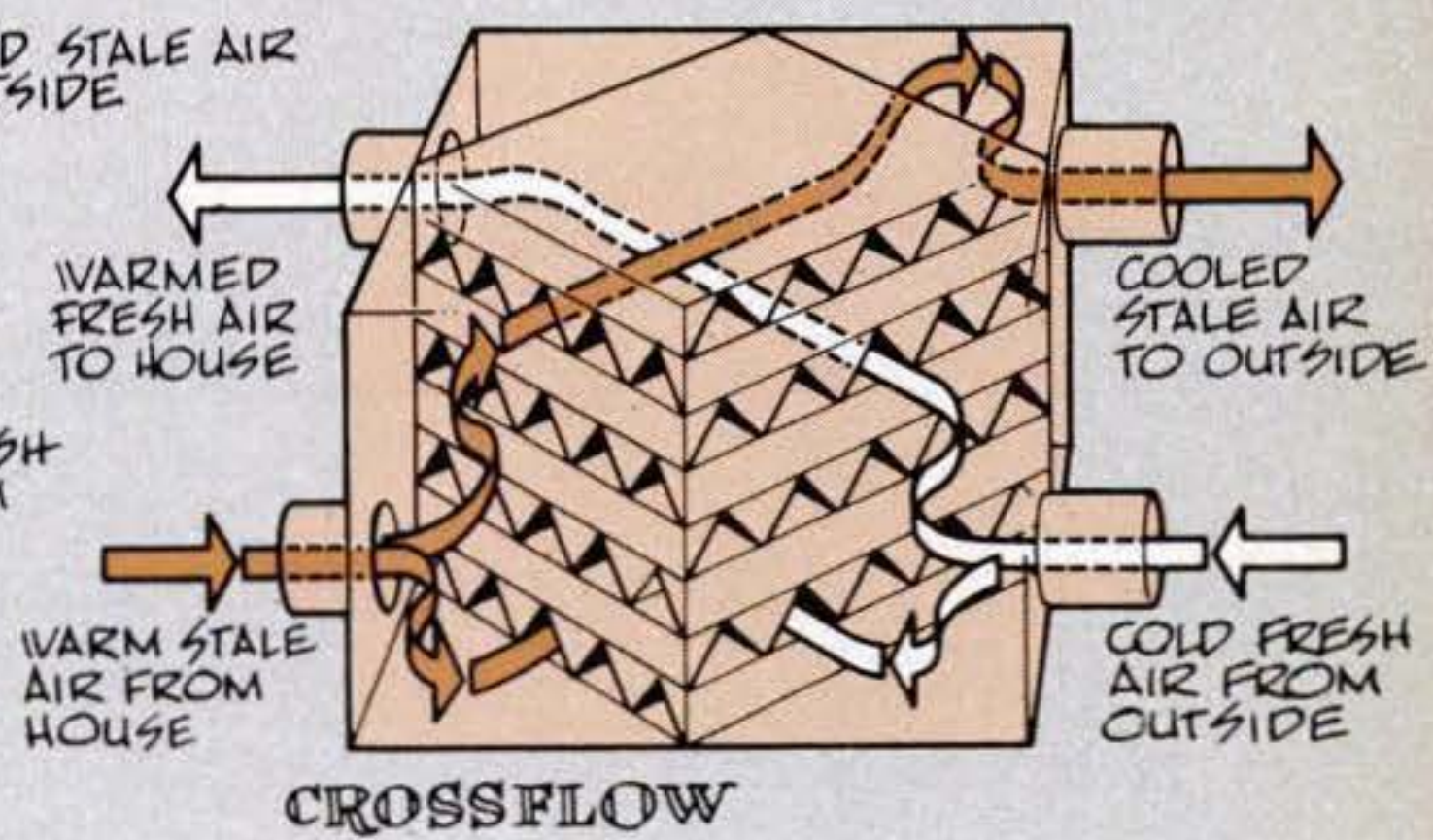
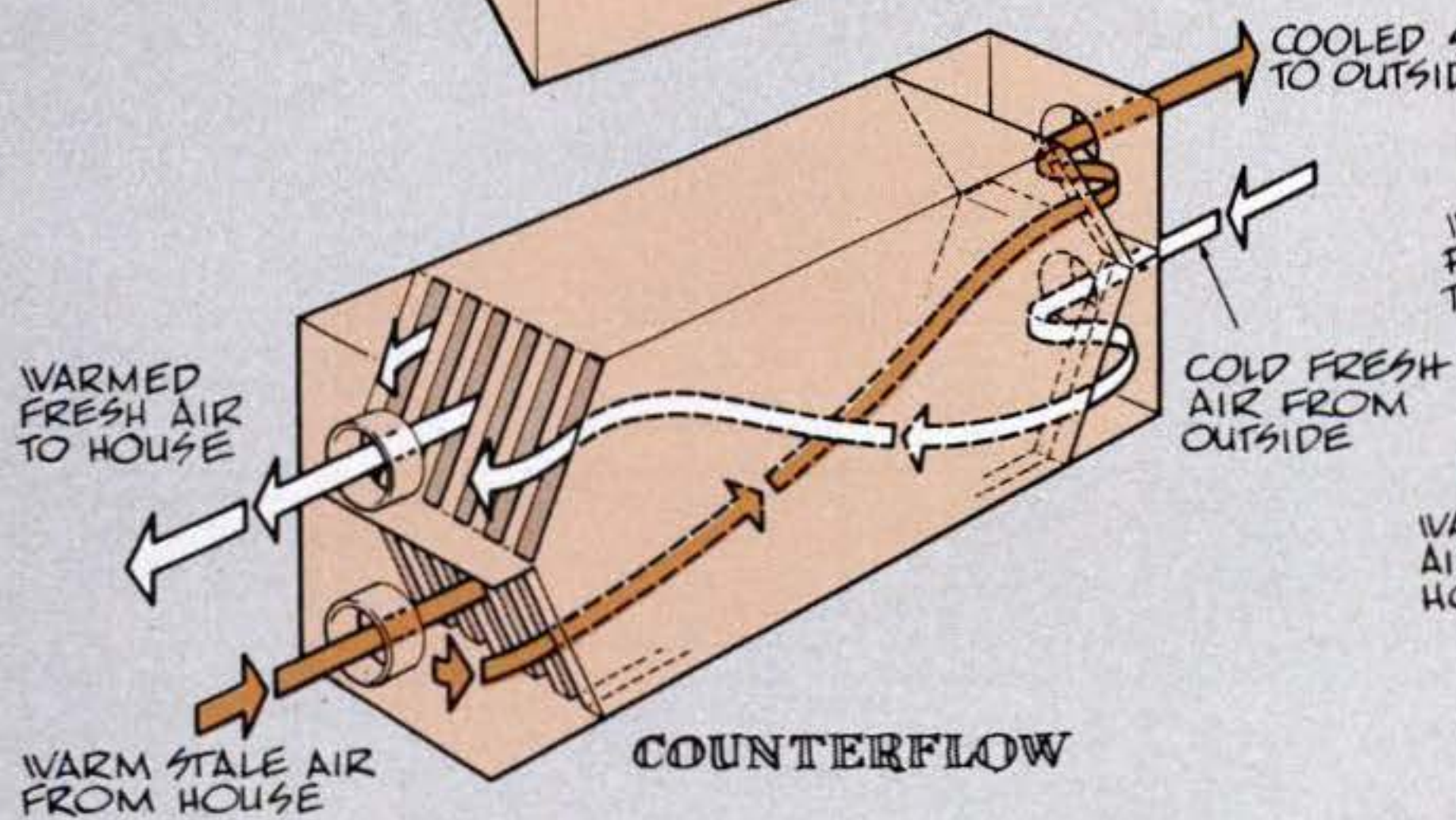
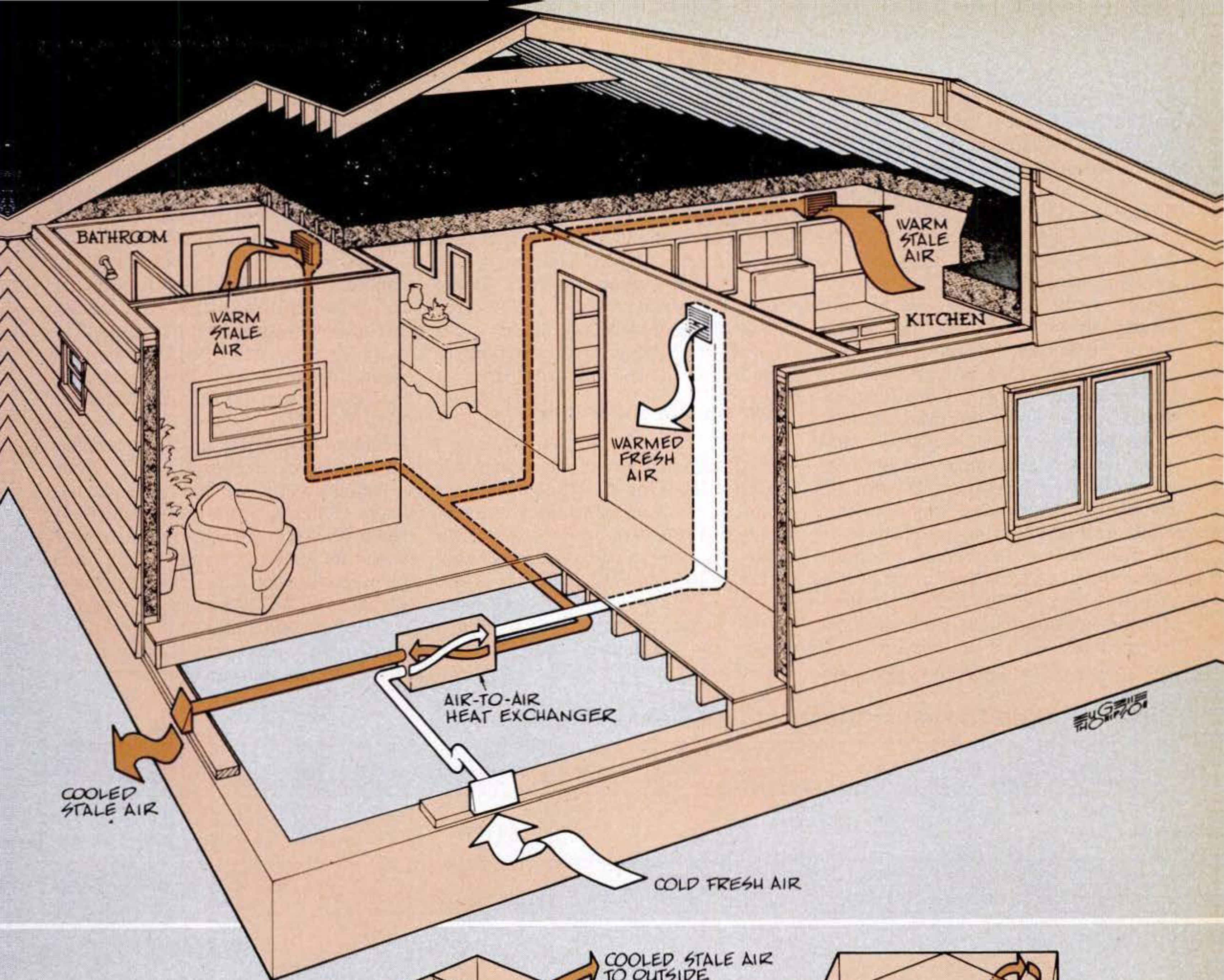
Like air conditioners, air-to-air heat exchangers come in two fundamental types: small window or through-the-wall models and larger ones that circulate air through ductwork (see diagram). Some manufacturers sell complete systems: the core, where the heat is actually exchanged, two fans (one to exhaust stale air, the other to bring in an equal amount of

fresh air), filters for both air streams, a control system, and the housing. Others sell only the core or just the core and housing.

The core itself comes in a variety of designs, classified as counter-flow, cross-flow, and rotary; and one company makes a core of heat pipes (see diagrams and explanation, below). The cores are made of metal, plastic, or treated paper. Some transfer moisture—water vapor—as well as heat.

Continued

Whole-house air-to-air heat exchanger is usually located in the basement ceiling, crawl space, or in a mechanical room. One fan brings stale air (dark arrows) from bathrooms, kitchen, laundry room, etc., through ducts and routes it through the heat-exchanger core, where it gives up much of its heat to incoming fresh air, brought through insulated ducts from outside (light arrows). The cooled, stale air is exhausted outside while the warmed, fresh air is delivered to living areas. Heat-exchanger cores come in a variety of types: Cross-flow units have tiny air passages in layers with each layer perpendicular to the adjacent ones. Air streams pass each other at right angles. In counter-flow heat exchangers, the two air streams flow parallel to each other but in opposite directions. (Air passages in the cross-flow and counter-flow diagrams are enlarged for clarity.) Rotary exchangers use a revolving wheel composed of tiny air passages. The wheel slowly turns from the warm-air stream into the cold, picking up heat from one and delivering it to the other. The rotor may also contain a desiccant, which absorbs moisture from the warm-air stream and gives it up to the cold one. Heat exchangers that have heat pipes in the core use counter-flow air streams. The warm-air stream vaporizes the refrigerant in the heat pipe, and the vapor flows to the other end, which is in the cold-air stream. The cold air causes the vapor to condense, releasing its latent heat.



These are often referred to as enthalpy exchangers or total heat exchangers, because they capture the latent heat in the water vapor as well as sensible heat. Actually, heat exchangers that do not transfer water vapor also capture latent heat in winter when the heat-transfer surfaces between the two air streams fall below the dew point of the outgoing (warm) air. Under those conditions, the water vapor condenses, releasing its latent heat—part of which is transferred to the incoming cold air. A drain is provided to take away the condensate.

"In winter, a heat exchanger that does not transfer moisture will be more effective in reducing the humidity level in your house," says William Fisk, staff scientist at the University of California's Lawrence Berkeley Laboratory (LBL), where much of this country's research on indoor air quality and air-to-air heat exchangers is being done. That's an advantage if your house is too damp in winter. But

in summer, when it's hot and humid outside, a heat exchanger that does transfer moisture can be an advantage. Much of the moisture in the warm, fresh air will be transferred to the cooler stale air and exhausted right back outside. That can reduce the load on your air conditioner.

Some heat exchangers have simple manual control systems; others have automatic controls regulated by a humidistat. Many heat exchangers also have frost-control systems.

How much ventilation?

A common measure of a building's ventilation rate is the air change per hour (ACH). One ACH means that a quantity of air equal to the volume of the house comes in and goes out each hour. Houses in the U.S. probably average between 0.5 and 1.5 ACH. But the LBL researchers have measured some recently built homes where the infiltration rate was reduced to 0.1 to 0.25 ACH.

While air flow in and out of a house is generally measured in ACH, a heat exchanger's fans are rated in cubic feet per minute (cfm). To find what cfm you would need to achieve a given ACH, you have to determine the volume of your house in cubic feet.

How much ventilation is enough? It depends on how rapidly pollutants are being generated within the house. Air-quality experts refer to this as the source strength. Where source strengths are low, a low air-change rate can be satisfactory. LBL and the New York State Energy Research and Development Authority tested several houses in Rochester, N.Y. They selected 10 of the houses—one rather leaky (1.17 ACH) and nine relatively tight (0.2–0.5 ACH)—and measured them for radon, formaldehyde, and nitrogen dioxide. The concentration of all these in all 10 houses was within existing standards for outdoor air and within any proposed standards for indoor air, though the leaky house had

Buyer's guide to residential air-to-air heat exchangers

Company	Model	Type	Core type	Core material	Air flow ¹ (cfm)	Claimed efficiency ² (% @ cfm)	Max. power consumption (watts)	Moisture transfer?	Sugg. list ³ price (\$)	Comments
The Air Changer Co. 34 King St. E. Toronto, Ont. M5A 1K8 Canada	Deluxe	Ducted	Counter-flow	Polypropylene	0–150	85 @ 150	68	No	798	Company does not generally quote free-air flow; 150-cfm-max. quoted allows for losses in heat exchanger and in about 200 ft. of ducts
Aldes-Riehs Box 157, Glenfield Rd. Sewickley, Pa. 15143	VMPI-5 VMPI-7 VMPI-H	Ducted	Counter-flow & cross-flow	Plastic	104 140 70, 90	69 @ 104 67 @ 140 65 @ both	100 125	No	2,550 2,714 1,950	Efficiency figures are from tests at LBL. Defrost control must be operated manually
Berner Int. Corp. 12 Sixth Rd. Woburn, Mass. 01801	Econo-mini 100 Econo-mini 500	Wall- or window-mounted Ducted	Rotary	Coated paper	31, 56 160, 225, 295	81 @ 31, 74 @ 56 78 @ 160, 73 @ 225, 70 @ 295	41 270	Yes	350–375 1,200	Listed air flow for the EM 500 includes losses in about 20 ft. of ductwork. Also available without moisture transfer
Conservation Energy System Box 8280 Saskatoon, Sask. S7K 6C6 Canada	VanEE R-200	Ducted	Double cross-flow	Polyolefin	0–200 (see comments)	83 @ 100, 71 @ 200	200	No	795	200-cfm-design air flow includes losses in heat exchanger and ducts. Distributed in U.S. by Solatech Inc., 7726 Morgan Ave. S., Minneapolis, Minn. 55423
Des Champs Laboratories Box 348 E. Hanover, N.J. 07936	E-Z Vent 79M.2 79M.4 79M.6	Ducted	Counter-flow	Aluminum	70 180 350	74 @ 70 73 @ 180 73 @ 350	170 224 338	No	500 546 736	Prices do not include controls. Defrost control is under development and can be added
Enercon of America 2020 Circle Dr. Box 632 Worthington, Minn. 56187-0632	207 158	Ducted	Counter-flow (concentric cylinders)	Polystyrene	70, 150 175, 250	80 @ 70, 70 @ 150 90 @ 175, 75–80 @ 250	80 80	No	995 1,295	In cold weather a defrost timer shuts off cold-air supply 20 min. of each two-hr. period. Efficiencies given do assume some condensation
Ener-Corp. Management Ltd. 2 Donald St. Winnipeg, Man. R3L 0K5 Canada	Enerex 250 Enerex 400	Ducted	Cross-flow	Polyethylene	250 (free) 400 (free)	92–96 @ 250 90+ @ 400	80 90	No	875 875	Electronic defrost control reduces cold-air flow as needed to avoid frost buildup
Memphremagog Heat Exchangers Box 456 Newport, Vt. 05855	Echo Changer R-1 R-2 R-3	Ducted	Counter-flow	Polypropylene	n.a. (see comments) 170 170	n.a. 70 @ 130 70 @ 130	n.a. 64 64	No	595 695 795	R-1 model includes no fans. R-2 and R-3 are identical except R-3 has a better case. Basic control package is \$115 extra. Efficiency was determined by company tests patterned after LBL tests
Mitsubishi Electric Sales America 3030 E. Victoria St. Compton, Calif. 90221	VL-500 VL-1500 VL-1500A LGH-50R2	Wall-mounted Wall- or window-mounted Ceiling-mounted Ducted	Cross-flow	Plastic Treated paper	23.5 28, 50, 71 40, 63 155, 220, 290	65 @ 23.5 76 @ 28, 73 @ 50, 70 @ 71 75 @ 40, 70 @ 63 76 @ 155, 73 @ 220, 71 @ 290	30 56 51 290	No Yes	107.25 330 344.40 1,427.50	VL-500 is for bathroom ventilation only. VL-1500 is also available with electric-resistance element for frost control, approx. \$450
Q-Dot Corp. 726 Regal Row Dallas, Tex. 75247	Thermal Recovery Unit	Used in ducted HVAC systems	Heat pipes	Aluminum	n.a. (see comments)	Depends on number of heat pipes	n.a.	No	See comments	Company sells only the heat-pipe core—in 400 sizes. A core large enough to use with 267-cfm fans would cost about \$250 and recover 67% of the available heat

Footnotes: 1) Air-flow rates are given for all available fan speeds. Generally they include losses (pressure drop) within the heat exchanger but not in ductwork; for exceptions, see comments. Where "free" air flow is indicated, the stated numbers do not account for losses within the heat exchanger. 2) Efficiency figures given are from the manufacturers and should not be assumed to be comparable. Some are based on calculations, some on computer modeling, some on actual tests; methods are not standardized. And real-life conditions degrade performance. 3) Prices usually include core, housing, two fans, filters, controls. Sometimes controls are extra. Ductwork and installation are extra.

even lower concentrations than the others. Still the tighter houses were judged to have generally satisfactory air quality because pollutant source strengths were low.

On the other hand, if source strengths are high, higher rates of ventilation are required to keep the air healthy. Indeed, sometimes more would be required than is practical. "For example," says Princeton's Dutt, "source strengths of radon may vary by a factor of 1,000, but by playing games with the ventilation you can't tweak the indoor concentration by more than a factor of three or four."

An added complication: There are no real standards for contaminant concentration in houses. Researchers now look to existing standards for outdoor air, standards for work places, and a few proposed guidelines for indoor air.

Another frustrating fact: It is very difficult to know if your house has a problem. How can you tell? Excessive humidity in winter is one clue. Odors that linger too long are another. You are more likely to have high concentrations of formaldehyde if your house is insulated with urea-formaldehyde-foam insulation or contains large quantities of new particleboard. Formaldehyde monitors are available from 3M (Box 43157, St. Paul, Minn. 55164) for \$35 (certified check or money order). High radon concentrations are more likely in geographical areas known to have high radium levels—uranium- or phosphate-mining areas, for example. Radon monitors are available from the Terradex Corp. (460 N. Wiget Lane, Walnut Creek, Calif. 94598) for about \$50. Nitrogen dioxide, carbon monoxide, and particulates tend to be higher in houses with gas ranges, especially if no vented range hood is used, and where any unvented combustion appliance is used. Another source of these three is tobacco smoking. Presently, no readily available monitors for these and most other pollutants exist.

If you do have an indoor-air-quality problem, will a heat exchanger solve it? It will probably help, but various factors can degrade a heat exchanger's air-cleaning ability. An important one is incomplete mixing of the air in the house.

"The Swedes say that unless the house is very, very tight, the other leaks short-circuit the ventilation scheme," says Dutt. "In other words, if you're exhausting air from the kitchen and have a leaky soffit there, replacement air will come in through the crack." For similar reasons, window- or wall-mounted heat exchangers may not effectively ventilate an

entire house or even a whole room.

The field tests in Rochester raised some additional questions. After the nine tight houses had been monitored for contaminants for a week, heat exchangers were installed in them and the average ventilation rate increased by 80 percent. Then the contaminants were measured again for a week. The result: The concentration of most pollutants decreased—some rather dramatically—but nitrogen dioxide increased. It seems the source of this culprit was outside, not inside, so bringing in more outside air brought in more of that pollutant. Furthermore, the two houses outfitted with heat exchangers that transfer moisture showed no reduction in formaldehyde concentration. "It's possible that formaldehyde was transferred between air streams in those models," the report says. But the researchers emphasize that this was a very limited sample and no conclusions can be drawn.

Until they are more thoroughly tested, about all that can be said is that most tests of most heat exchangers indicate that they do reduce most indoor pollutants most of the time.

Do they save much heat?

A heat exchanger's efficiency (often called effectiveness) is stated as a percentage of the theoretical maximum—the difference between the temperature inside the house and that outside. For example, if indoor air is 70 degrees F, outdoor air 30 degrees, and the temperature of the fresh air from the heat exchanger 60 degrees, it has raised the temperature of the outside air by 30 degrees, or 75 percent of the theoretical maximum (40 degrees). So the heat exchanger's efficiency is 75 percent. Efficiency decreases with increasing air-flow rates.

Manufacturers generally claim efficiencies ranging from 70 to 90 percent. Lawrence Berkeley Lab has tested 10 models over the years and come out with somewhat less optimistic figures: 45 to 85 percent.

The amount of energy and money heat exchangers save (compared with natural infiltration or forced ventilation without heat recovery) depends on how much energy the fans use as well as how much heat is saved. That depends primarily on the efficiency of the fans and motors. As the table on the previous page shows, wattage ratings of the fans of similar air-flow rates vary significantly.

Most companies claim their heat exchangers will pay for themselves in energy savings in two to five years. Some probably will under some conditions, but those conditions may

be rare in U.S. homes, according to a recent economic analysis by a team at LBL (see table below).

The conclusion: Payback periods ranged from five to more than 30 years in the four cities evaluated. The heat exchanger's efficiency and fan power consumption, the climate, and the cost of heating fuel are the strongest factors influencing the economics. "Consumers should be willing to pay significantly more for good performance," the researchers say. "But if a low ventilation rate (less than 0.5 ACH) is adequate to provide suitable indoor air quality, even a high-performance heat exchanger will be cost-effective only in the coldest climates."

Experts generally agree that, where possible, eliminating or reducing pollution emissions at their source or spot-ventilating the polluted area should be the first resort. But when that's not possible, increased ventilation may be your best route to clean air. Should you do it with a heat exchanger? That's a complex question; you should carefully evaluate how much it would cost to install one in your house, how much you pay for fuel, and the severity of your climate before you decide. E 5

Life-cycle cost-effectiveness of heat exchangers

City (Heating degree- days—°C)	Heating fuel	Payback period (years)	
		Case A*	Case B*
Minneapolis (4,657)	Gas	>30	12
	Oil	22	7
	Electricity	20	6
Chicago (3,688)	Gas	>30	19
	Oil	>30	9
	Electricity	17	5
Washington, D.C. (2,347)	Gas	>30	16
	Oil	>30	11
	Electricity	>30	9
Atlanta (1,645)	Gas	>30	29
	Electricity	>30	25

*Case A assumes that the typical house and the tight house have 0.6 ACH, with the heat exchanger providing 0.4 ACH for the tight house and infiltration providing the remaining 0.2 ACH. The heat exchanger is assumed to be 65 percent efficient, draw 200 watts, and cost \$1,300, installed. Case B assumes both houses have a 0.75 ACH, with the heat exchanger providing 0.55 ACH of that. This heat exchanger is 75 percent efficient, draws 140 watts, and costs \$1,150, installed.

Economic analysis by Lawrence Berkeley Laboratory compares two "typical" houses with given infiltration rates with two "tight" houses that use a heat exchanger to match those air-change rates (see footnote). The researchers looked at four cities in different climate zones and three types of heating fuels. The question: Considering the energy saved by recovering much of the heat from the stale air, how many years will it take to recover the additional cost of building a tighter house and installing and operating the heat exchangers? (The full report is to be published in an upcoming issue of *Energy and Buildings*, q. 200 Fr. Elsevier Sequoia S.A., Box 851, CH-1001 Lausanne 1, Switzerland.)

Clever places to hide heat-storing salts

Newly improved Glauber's salt mix is sealed in foil packets to fit everywhere

By **ERIK H. ARCTANDER**

ILLUSTRATION BY ADOLPH BROTMAN

Soon you'll be able to tuck packets of heat-storing salts into niches all over your house. They'll soak up solar and waste heat by day and radiate it back by night.

A technological double play made this new energy-saving device possible. First, researchers at the University of Delaware's Institute of Energy Conversion found a way to make Glauber's salt retain its original effectiveness for thousands of phase changes. By mixing the salts with a clay that reduces chemical breakdown, the scientists say they've given this formerly short-lived phase-change material a 15-year life.

Second, the Du Pont Co. has developed a thin film of laminated, metalized film to package the thickened salts. These new Thermostor packets take little extra space, as the drawing shows. PS

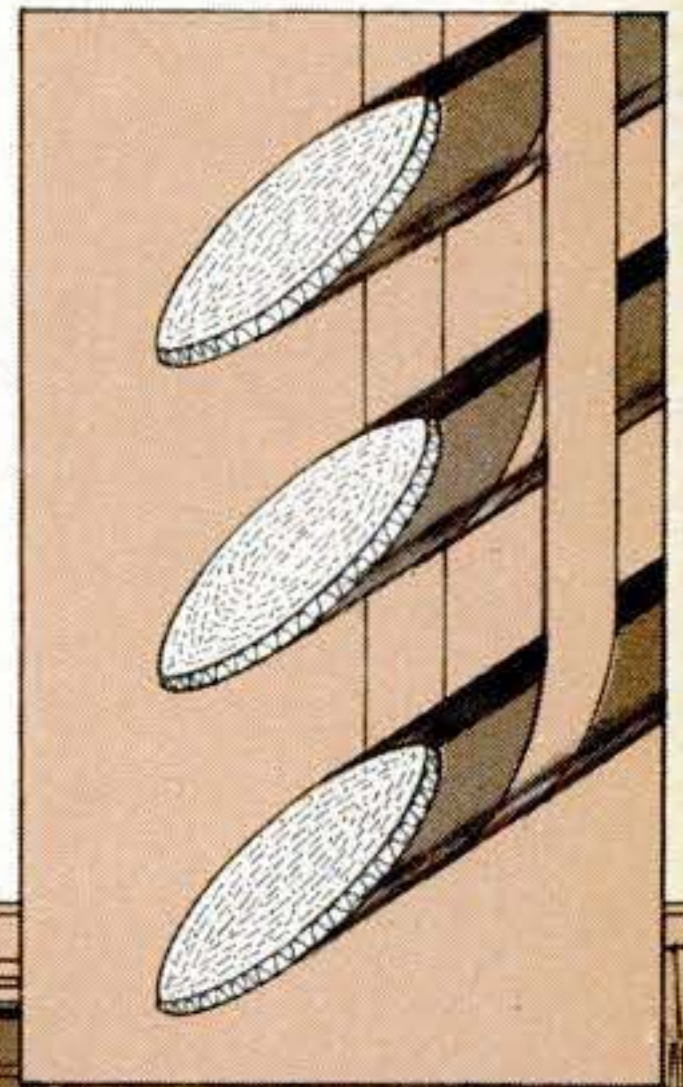
Solar greenhouse uses salts to even out daily heat fluctuations. Cabinet under planting bed houses stacked cylinders that absorb heat in daytime, keep bed warm at night. Or cylinders could be laid in shallow floor-to-ceiling rack against outside of house wall. Packets of salts, sized to fit the hollow cores of cement blocks, increase the heat-retaining ability of the masonry floor. These ideas will work on a sun porch, too. Insolar Inc. (212 E. Main St., Port Jervis, N.Y. 12771) makes the salts and will sell three different formulations: One is activated at 90 degrees F, one at 70, and one at 50. Price will be about 35¢ a pound.





Suspended-ceiling panels support flat packages of phase-change salts. Besides picking up waste heat from directly below the ceiling, they capture excess heat—thrown off by lighting fixtures—that's trapped in the space above the panels.

Venetian blind, with oval-shaped packages of salts instead of slats, collects heat when you turn the black side out and reflects it when you turn the shiny side out. To control the amount of heat stored, vary the angle of the package.



Heat-storing furniture includes an armchair with rack for cylinders built into or onto the arm facing a window. Hexagonal hassock on wheels could be built to hold cylinders or flat packets, then rolled into the sun during the day, in front of a chair at

night. Storage cabinet with trays for flat packets is called a Heat Sponge. It was designed to cool a room in summer by soaking up excess heat. But it's just as useful for storing heat on a winter day for release later, when needed.

Suspended between floor joists, flat packets store waste heat from a furnace in an unfinished basement. When remodeling or building new, they could be put wherever the floor above gets warm from the sun or from a wood stove or fireplace.

Faster fire sprinklers for your home

Quick-trigger sprinklers are here now. And on-off heads may be next

By TOM JOHNSON

SAN FRANCISCO

The mayor of San Francisco appeared uncomfortable even though she was sitting on a sofa next to her friend Andy Casper, then chief of the city's firefighters. The two officials were in a room specially built in a vacant lot here for the annual convention of the National Fire Protection Assn. The mayor was going to set that room ablaze and stay in it until the fire was out.

As reporters, photographers, and TV cameramen jockeyed for position at the other end of the 20-foot-square frame structure, Dianne Feinstein stood, tugged a rubber firefighter's coat down over her plaid skirt, and pulled her scarf just a bit tighter. She knelt in front of a wicker wastebasket stuffed with newspapers, and struck a match.

The mayor returned to the couch and stared in fascination as flames licked up the curtains and wall. Within seconds the room filled with smoke as thick as fog at the Golden Gate.

The mayor and the chief, sitting stoically on the couch, were quickly obscured; only muffled coughing signaled that the two were still in the room. In less than 35 seconds smoke alarms were rasping; 22 seconds later an 18-gallon-per-minute shower opened up from the ceiling. Ninety seconds after the sprinkler turned on, the blaze was out, and Mayor Feinstein walked out of the test room, wet but alive.

Sure, it was a publicity stunt, but one with life-and-death significance. The mayor and the chief were playing roles in a national effort to reach the public with the message that nearly 6,000 Americans don't have to die in residential fires each year.

As reported one year ago [PS, Jan. '82], fire-prevention officials hope a new generation of residential sprinklers just reaching the market can cut those deaths and \$2.8 billion in property losses by at least 50 percent in coming years. Since that first report, which focused on the Grinnell Fire Protection Systems Co.'s F954 Residential Sprinkler, two additional sprinkler designs have satisfied requirements set by Underwriters Laboratories. Insurance companies are now considering rate cuts for homeowners who install the systems. And an estimated 30 to 40 cities and counties are requiring the sprinklers in new residential construction.

In still other communities, according to Grinnell's John Viniello, local fire officials are making code trade-offs with developers. If, for example, a developer installs a sprinkler system in a high-density development, local inspectors might let him save money by using standard wallboard instead of a more expensive material with a higher fire rating. "Fire-protection people want to encourage sprinkler installation by creating economic advantages for builders—not by mandating the sprinklers, which alone could push up housing costs," Viniello told me.

Why the sudden interest in sprinklers for the home? "These new residential heads, which trigger at about 140 degrees F, react five times faster than the industrial heads," Harry Shaw, an assistant administrator of

the U.S. Fire Administration, told me. That's essential for homes, in which typical fires smolder for long periods. Highly flammable hot gases build up and then ignite—or cause flashover—seconds after flames break out.

Quicker triggers

The major design challenge for developers of faster sprinklers was the trigger. "The head has to trigger before lethal toxic fumes build up. Yet it can't be so sensitive as to be turned on by heat or smoke from stoves or cigarettes," says Fire Marshall Gary Carmichael of San Clemente, Calif., the first city to require the systems in new residential construction.

The Grinnell sprinkler trigger is copper, held in the closed position with a low-temperature solder. Heat builds up, the solder melts, and a plug falls out, releasing the water flow.

A second head design developed by Central Sprinkler Corp. in Lansdale, Pa., and just now coming onto the market, uses a bimetal disc similar to that in a thermostat. The disc is concave in the "off" position. As temperature builds (to either 135 or 160 degrees F, depending on the model's rating), the outer metal expands and pops the disc into a convex shape. That action pulls a plug from the sprinkler, releasing the water. "Our head will operate with only 23 psi of water pressure," Bill Meyer, president of the company, said. "And the sprinkler head is installed nearly flush with the ceiling."

Both heads were extensively field-tested in two new \$70,000 houses in Scottsdale, Ariz., last April. Observers from Sentry Insurance Company monitored each test and concluded that the sprinkler systems prevented a total of \$98,000 in damage to both



Flames burst from a wastebasket (left) but are doused seconds later (right, from another angle) by new sprinklers during a demonstration in San Francisco. Quicker to respond than sprinklers intended for in-

homes. It's not surprising, then, that the insurance industry is about to encourage residential sprinklers.

"Our actuaries are cranking through the numbers to establish a discount for homeowners in Arizona who install the sprinkler systems," Chris Behymer, a Sentry Insurance marketing executive in Scottsdale, said. "We are looking at going to a 20 to 25 percent discount on the total homeowner's insurance premium."

In Arizona, about 40 percent of a homeowner's premium is related to fire coverage. In other areas with different disaster potentials—tornadoes in Kansas, hurricanes along the Gulf Coast, or slow-responding fire departments—the discount for a sprinkler system might be less, insurers say.

Stopping the flood

Rates might even be lower if and when a sprinkler head is developed that can shut itself off when the fire is out. Battelle Laboratories in Columbus, Ohio, is working on this, using a nickel-titanium alloy called Nitinol, the "metal with a memory."

"When a conditioned Nitinol spring

dustrial and commercial buildings, the new heads also have a spray pattern designed to combat residential fires. The fanlike spray delivers more water to the walls and sides of a room, where highly

is heated to its shape-critical temperature, it will unwind," says Jerry Harris, who headed the study for Battelle. "Then, upon cooling, it will return to its original shape at room temperature. This has the potential for producing a heat-sensor component that would automatically turn a sprinkler on and off at prespecified temperatures."

Battelle has successfully tested the "on" component of the Nitinol head, and is awaiting funding to develop the hardware related to the "off" mode. The laboratory also has tested an electrically triggered head, which, according to engineer Stan Kleszczelski, could respond faster, perhaps in less than five seconds.

"On-off heads have some obvious attractions to the insurance industry, because they won't turn a house into a swimming pool," said Ralph Jackson, an Allstate Insurance executive and chairman of an insurance-industry committee established to evaluate the sprinkler systems.

The Grinnell Co. is also introducing a sidewall sprinkler designed for residential use. The sprinkler mounts on

flammable draperies and furniture are found. Unlike older heads, the new ones don't require a separate, high-pressure water line; they work off a home's ordinary water supply.

the wall several inches below the ceiling. It requires higher water pressures than the ceiling-mounted version but is easier to retrofit. An added money-saving advantage is that one pipe in an interior wall could supply sprinklers in two different rooms. Piping in a wall would also reduce the possibility of pipes freezing.

As a final cost-saving factor, some states and communities already have approved polybutylene (plastic) piping for residential sprinklers. "It's 40 percent cheaper than iron pipe and excellent for retrofitting an existing house," Harry Shaw says.

How much is a retrofit? Experts estimate 1.5 to two percent of a home's value—typically \$1,500 to \$2,000 for a professional installation. Most experts insist that the variables of water pressure, water flow, and location of sprinkler heads are too critical for many amateurs to tackle. But odds are that coming months will see do-it-yourself kits on the market.

"These sprinklers will make the room where a fire starts survivable," Shaw says. "You may get a bellyful of smoke, but you survive."



Portable compressor

packs 100 psi

Power Pal compressor mates with etcher, sprayer, and caulking-cartridge holder. Knob at top selects pressure: 10 to 100 psi.

It's powerful enough for most chores, but the sprayer tends to spatter

By E. F. LINDSLEY

Compressed-air power can be a valuable helper around your house and yard—especially if the compressor is light enough to tote up ladders, powerful enough to blow out dust and dirt, and easily adjustable in pressure. Combine these characteristics in one machine and add a kit of matched accessory tools—spray gun, material dispenser, and sandblast etcher—and

you have the new Campbell Hausfeld Power Pal.

If you've had experience with small, portable compressors, you know that they often peak out at about 40 psi. That's enough for some spraying jobs, but too low for pumping up racing-bike tires, blowing out hydraulic lines, or air-jet cleaning. But the Power Pal can handle these jobs easily. It has an adjustment knob on top to let you dial in any pressure from 10 to 100 psi—a lot of air from an oilless twin-piston compressor that weighs only 22 pounds.

My first check of the Power Pal showed that it ran smoothly without the common tendency to hop around.

Moreover, the 120-volt, nine-amp, split-phase motor didn't seem to have the starting problems I've seen in many small compressor motors.

The material dispenser, etcher, and disposable spray gun all attach to the same handle with quick-disconnect threads. The molded-plastic handle contains a trigger-type air valve. The spray gun, etcher-material cup and head, and material-dispenser canister are also plastic.

I've always washed a spray gun after use, and I saw no reason to treat this one any differently. To find out what would happen to the plastic material in cleaning solvent, I soaked the gun head in acrylic lacquer thinner

for 24 hours. The only apparent effect was a slightly frosty appearance on the plastic surface.

The Power Pal instructions say that you should thin paint to a sprayable consistency. That's fine for some paints but not others. When I tried using thinned Du Pont acrylic lacquer, the gun proved disappointing: It sattered rather than sprayed. Thick latex house paint was another impossibility.

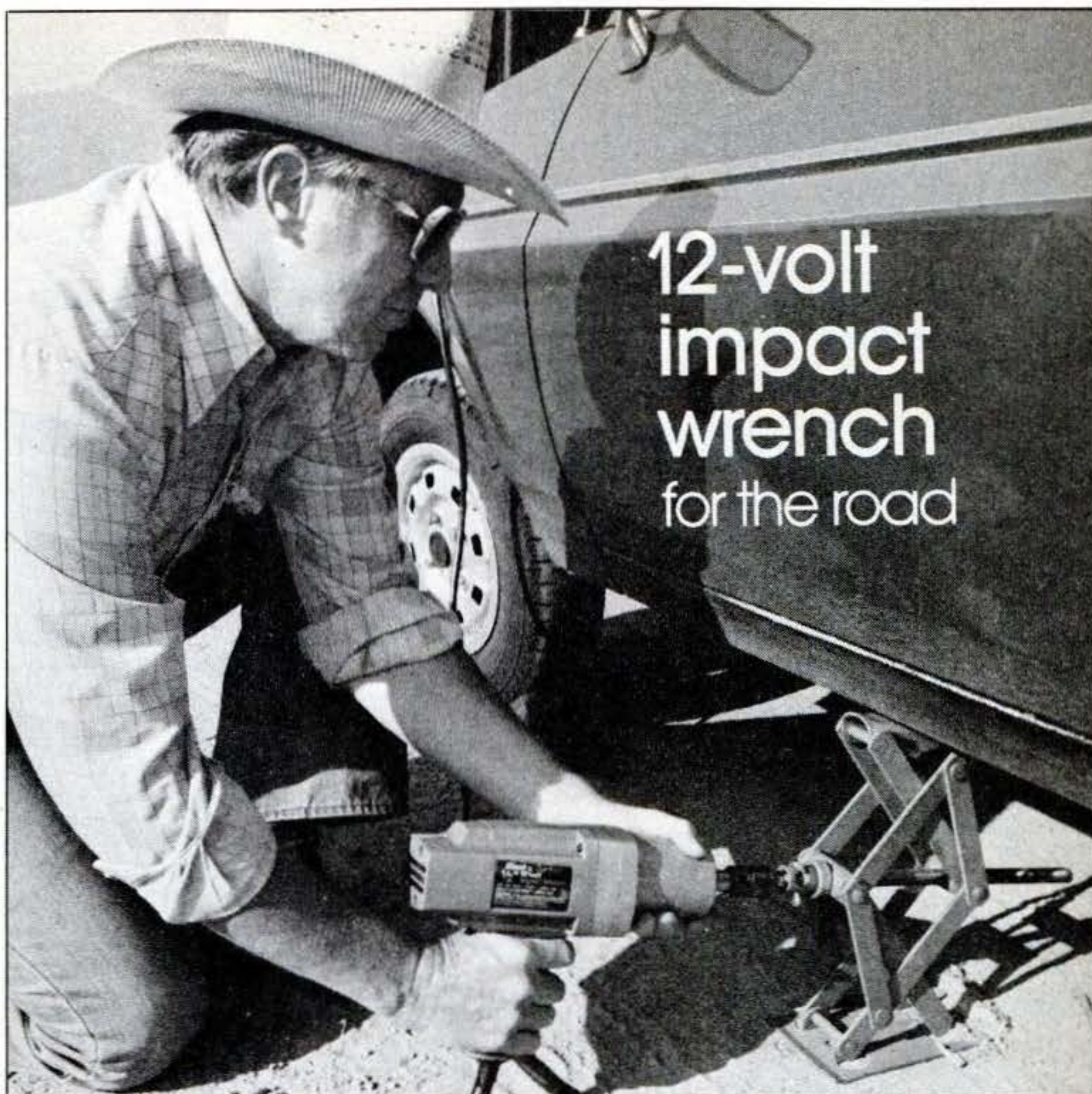
Suspecting that the plastic gun had limitations, I tried it with ordinary household enamel—the kind you might use on toys, yard furniture, and other not-too-fussy jobs. This time performance was acceptable, but not all it could be, especially if you're used to better spray guns. To check my judgment, I dumped the unused enamel from the plastic gun into a Binks automotive-type spray gun and hooked up the Power Pal compressor. It worked normally, with a finely atomized, well-patterned spray.

My conclusion? If rough-and-ready spraying is all you need, the plastic gun should be satisfactory. But if you want to lay on fine finish coats of lacquer, varnish, or enamel, you'd be better off buying a standard gun.

The etcher is a small, cup-type sandblaster. Unfortunately, sandblasting is a job that calls not only for lots of air pressure but for plenty of air volume, as well. The Power Pal delivers 2.5 standard cubic feet per minute (scfm) at 40 psi, so at 100 psi the volume is limited (the company claims one scfm at 90 psi). In addition, the etcher's sand pickup tube is a plastic tube about the size of a soda straw. For hobby use, cleaning up small tools and welds, or perhaps even removing old varnish from carved areas of antique furniture, the etcher might be useful. Don't expect it to strip a garden tractor for repainting, however.

If you've ever pumped a caulking gun for hours, you'll really appreciate the Power Pal's material dispenser. You merely tuck a standard cartridge of caulking, adhesive, crack filler, etc., into a plastic cylinder and screw it onto the power handle. You adjust air pressure to suit the material and the speed you choose to work, and the air pressure does the squeezing.

Campbell Hausfeld (100 Production Dr., Harrison, Ohio 45030; 800-543-0302) sells the Power Pal for \$150. Standard equipment includes a 15-foot air hose, air chuck, inflator needle, mattress inflator, and quick-disconnect adapter. Two accessory kits are available: sprayer, material dispenser, blower, and power handle for \$30—and the same kit with etcher for \$50. The etcher alone costs \$30. **UE**



Twisting a lug bolt on a jack, the portable impact wrench can lift a car in seconds.



Tire changing is easy: Battery cord for B&D Model 9518 is 17 ft. long. That's enough to reach all wheels on a car.



Split-ring retainer on 1/2-in. drive takes special impact sockets, necessary for safety. Don't use regular sockets.

I tried Black & Decker's new 12-volt 1/2-inch-drive impact wrench and found it to be a handy tool. It's easily carried in a car, light truck, or RV, and it easily spins lug nuts and bolts on and off.

To power the eight-pound Model 9518 wrench, you clip on its color-coded leads: Red goes to the car battery's positive terminal; black goes to an engine ground. The plastic-body tool draws 19 amps, about the same as four headlights on high beam. A good battery, says Black & Decker, can provide 25 wheel changes and still have plenty of reserve power left for starting.

With a car battery delivering 12.2 volts, I found that the wrench would produce some 70 foot-pounds of torque. That is, after 10 seconds of im-

pact load, it took 70 foot-pounds of force, registered by a torque wrench, to tighten any further. Black & Decker (3012 Highwoods Blvd., Raleigh, N.C. 27625) claims up to 100 foot-pounds. The 70 I got was ample to handle even the wheels on my 3/4-ton pickup, so I have no complaints.

One negative note: At first a little lubricant leaked from the tool's drive-shaft bearing, but that soon stopped. It was probably overlubricated to begin with.

While the Black & Decker 9518 was designed primarily for car-wheel changing, you'll find many other uses for it. For example, it's unbeatable at running lag screws. And, with an accessory impact chuck, you can drill, sand, and polish. It sells for about \$100.—*Richard Day*

Clever lighting tricks for **brighter bathrooms**



Bathroom too dim—or way too bright? Adding a canopy with a diffuser can solve both problems

By **SUSAN RENNER-SMITH**

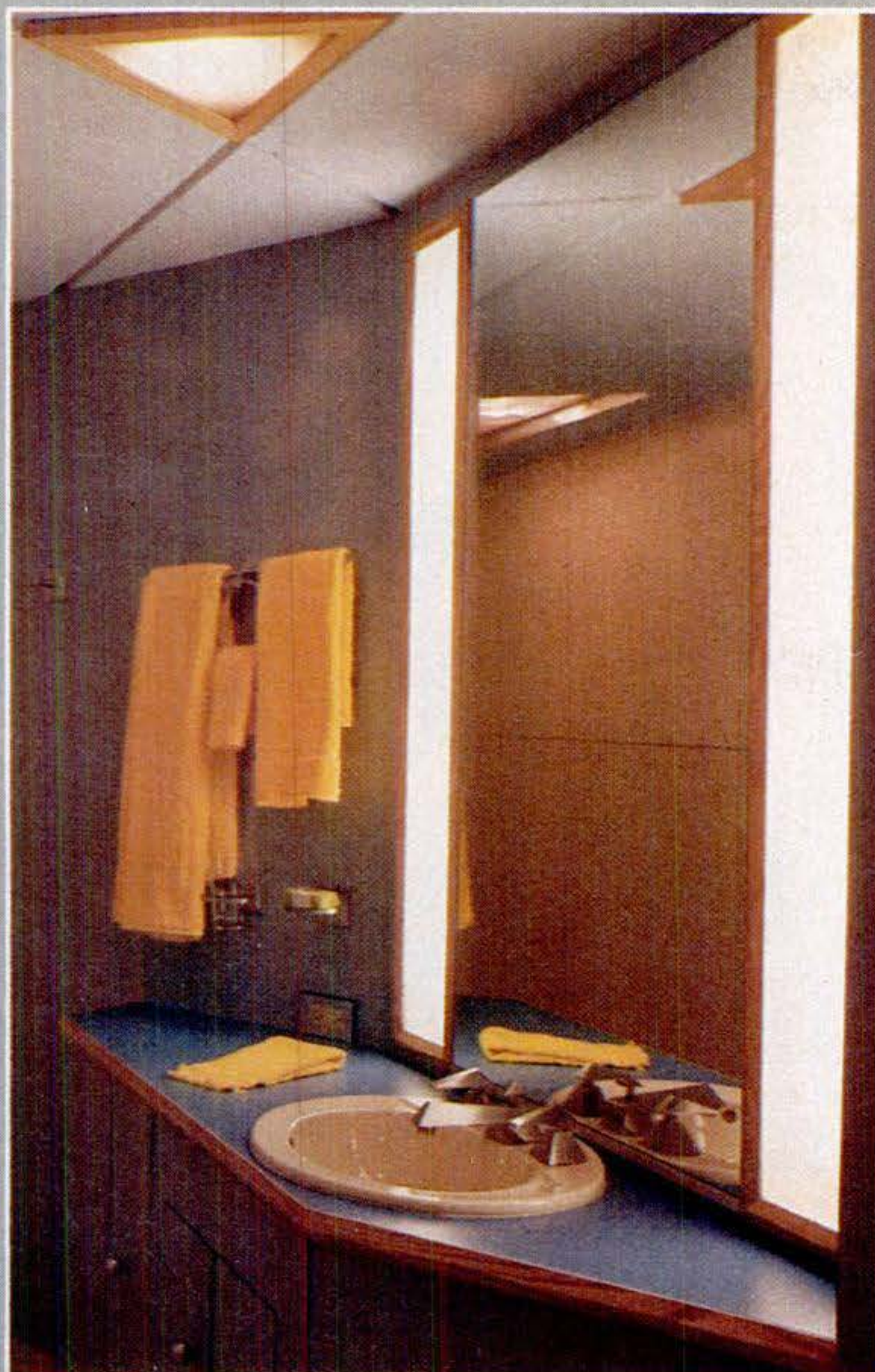
Lighting a bathroom effectively is not as simple as it seems—especially with today's decorating schemes. The old-fashioned, all-white bathroom may have been boring. But at least it was bright enough for the essential grooming tasks.

A modern bath decorated in warm earth tones may not be. Those elegant, warm woods and rich-colored fixtures suck up light. Unless properly lit, such rooms can be dark and foreboding instead of warm and welcoming.

Another contemporary style, the bold, jazzy look, is just as hard to light correctly. Primary colors, lively patterns, and shiny tiles may look harsh and glaring, tiring you out instead of pepping you up.

Yet proper lighting is as important in the bathroom as it is in any other work room. The basic need is glare-free, shadowless light for grooming. But you may also want gentler light for when the bathroom doubles as a powder room. And at least one member of every family likes to

Bright colors and busy patterns aren't overwhelming, thanks to diffuse lighting from curved soffit over the vanity (above) and lighted soffits over the bath and bidet (left).



Soft lighting (above) is still bright enough to offset the dark, light-absorbing vanity and wall. The same efficient, shadowless light is provided by the three light fixtures as by theater lighting

read in the bathroom, so a good reading light is a nice touch.

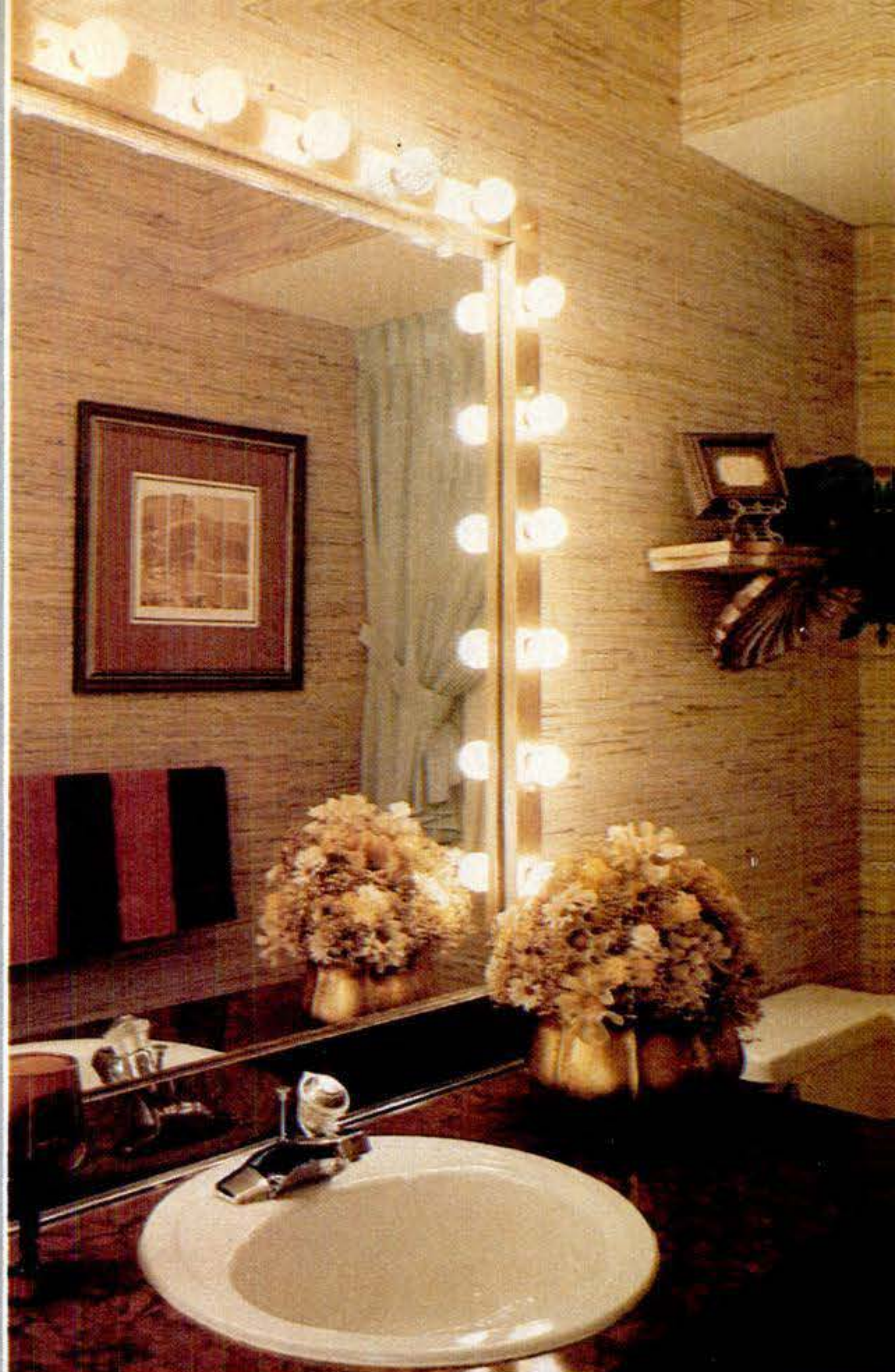
Careful planning can meet these needs while overcoming the problems caused by too dark, or too bright, contemporary bathrooms. Diffused light is the first solution for both. It softens any harshness in bright bathrooms while letting you use as much light as needed to brighten up overly dark rooms. To provide diffused light, simply cover light fixtures with highly translucent, milky white glass or plastic (see photos for examples).

In most cases, diffused light is good even for the shadowless task light needed for grooming. According to the lighting experts at GE, the best grooming light comes from fixtures on each side of the mirror as well as from overhead. Lights around the mirror can be enough to illuminate the average (under 75 sq. ft.) bathroom. And three properly placed, diffused light fixtures will do the job as well as a whole frame of dressing-room bulbs, according to GE.

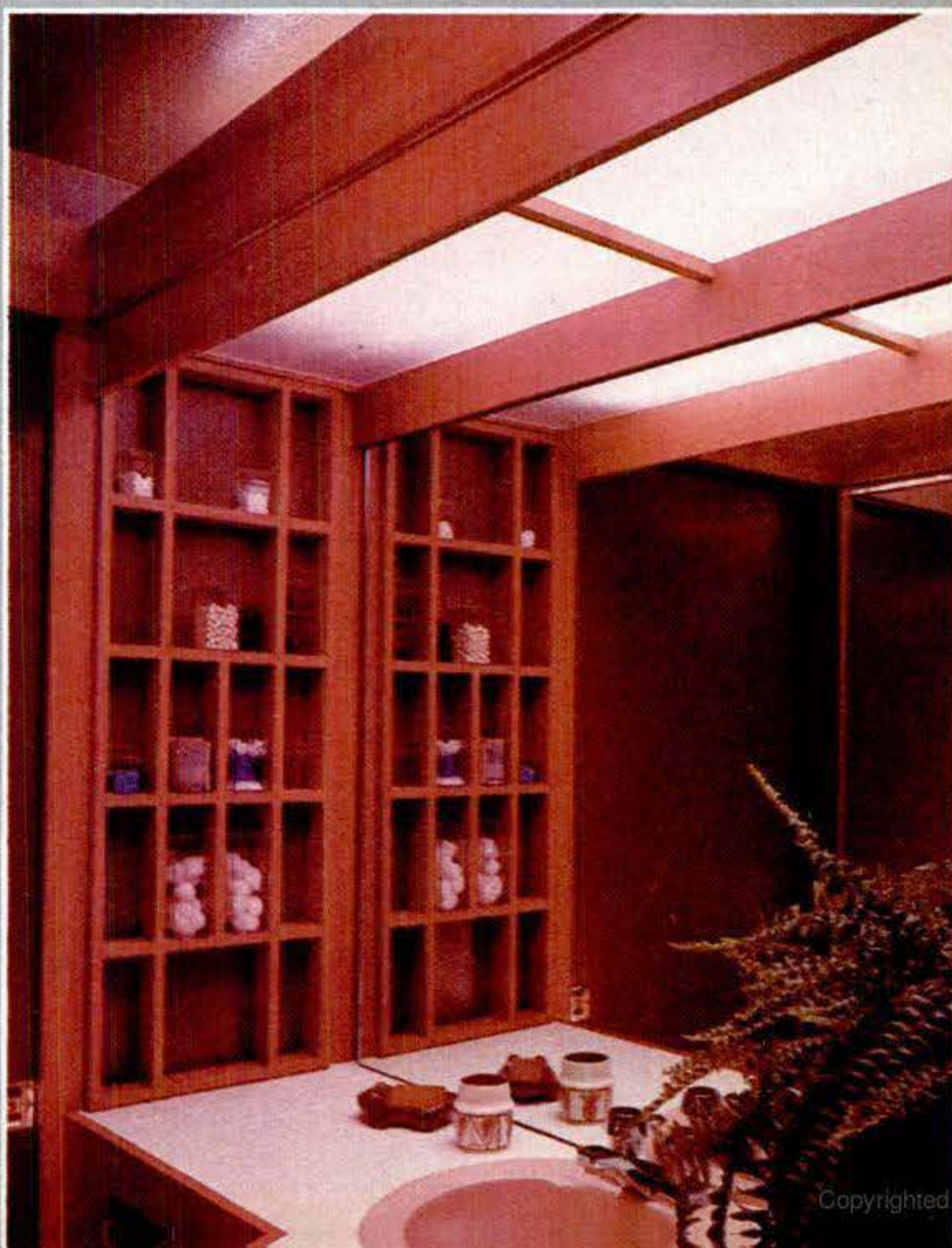
In the photos above, the mirror with theater lights has 18 globe lamps of 15 watts each, giving 50 foot-candles of light on the face. The mirror lighted by diffuse fixtures has two 40-W, soft-white fluorescent lamps recessed behind plastic lenses. The triangular ceiling fixture houses a

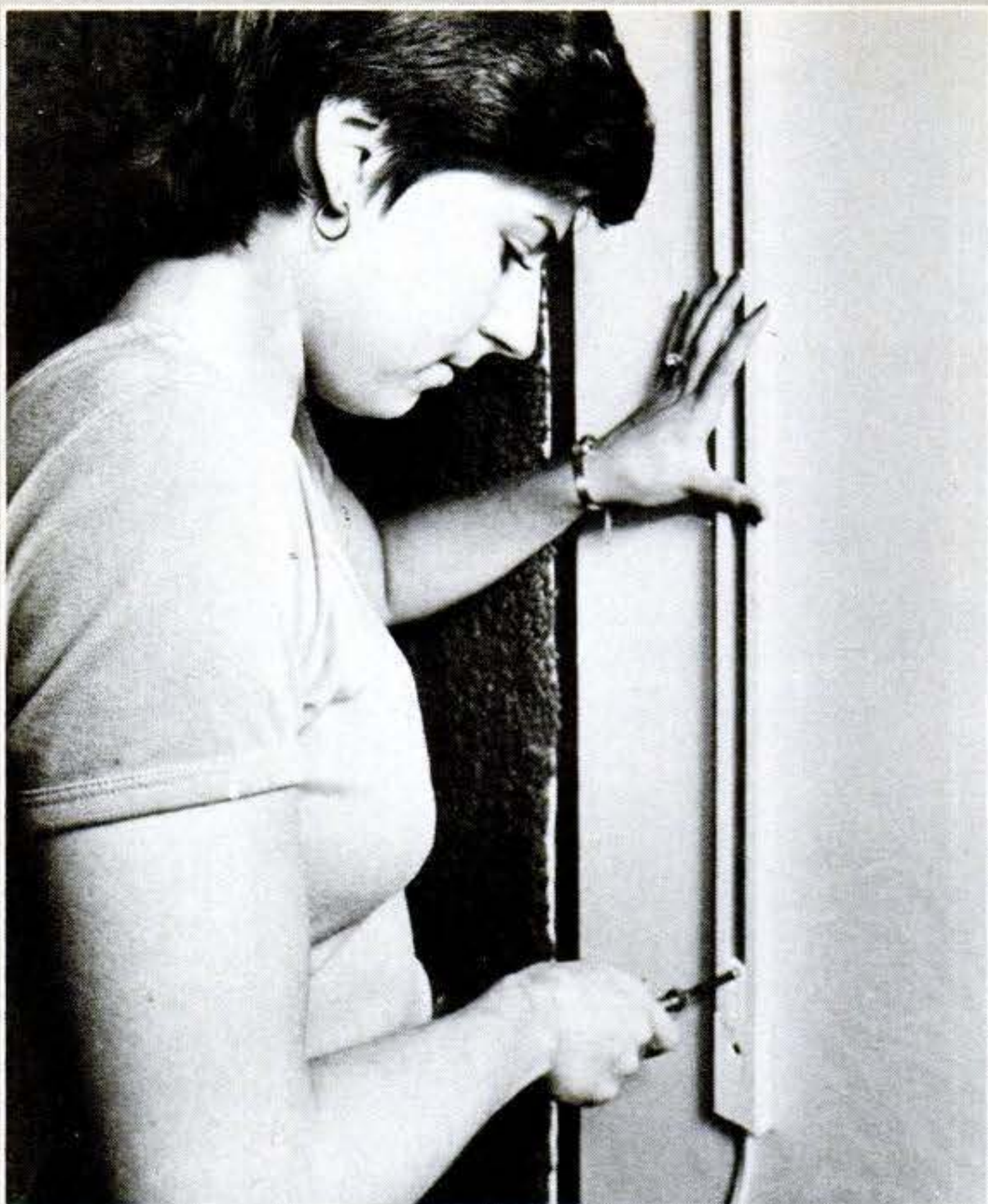
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Both uplight and downlight come from a floating soffit. To achieve diffuse effect, mount two rows of warm-white fluorescents above mirror. Bounce light from vanity aids grooming.



(right), which, of course, draws more wattage. But the incandescent bulbs surrounding the mirror can be placed on a dimmer—an advantage when guests use the bathroom.





Mounting the Halo Power Trac vertically on a wall (above) is simpler than installing on the ceiling—and makes the track ideal for lighting bathroom mirrors. New, frosted-shade fixtures from

60-W lamp. This is much less overall wattage than the theatrical lights. But thanks to the diffusers, which spread the light out evenly, this arrangement provides at least 80 foot-candles of light directly on the face.

Incandescent lamps can be used as well as fluorescent if they have diffusing lenses or frosted shades. For small mirrors, the side fixtures can be two wall brackets or hanging lamps, with a minimum diameter of six inches. They can take one 75-W or two 40–60-W soft-white bulbs in each. Sidelights should be centered 60 inches above the floor and at least 30 inches apart.

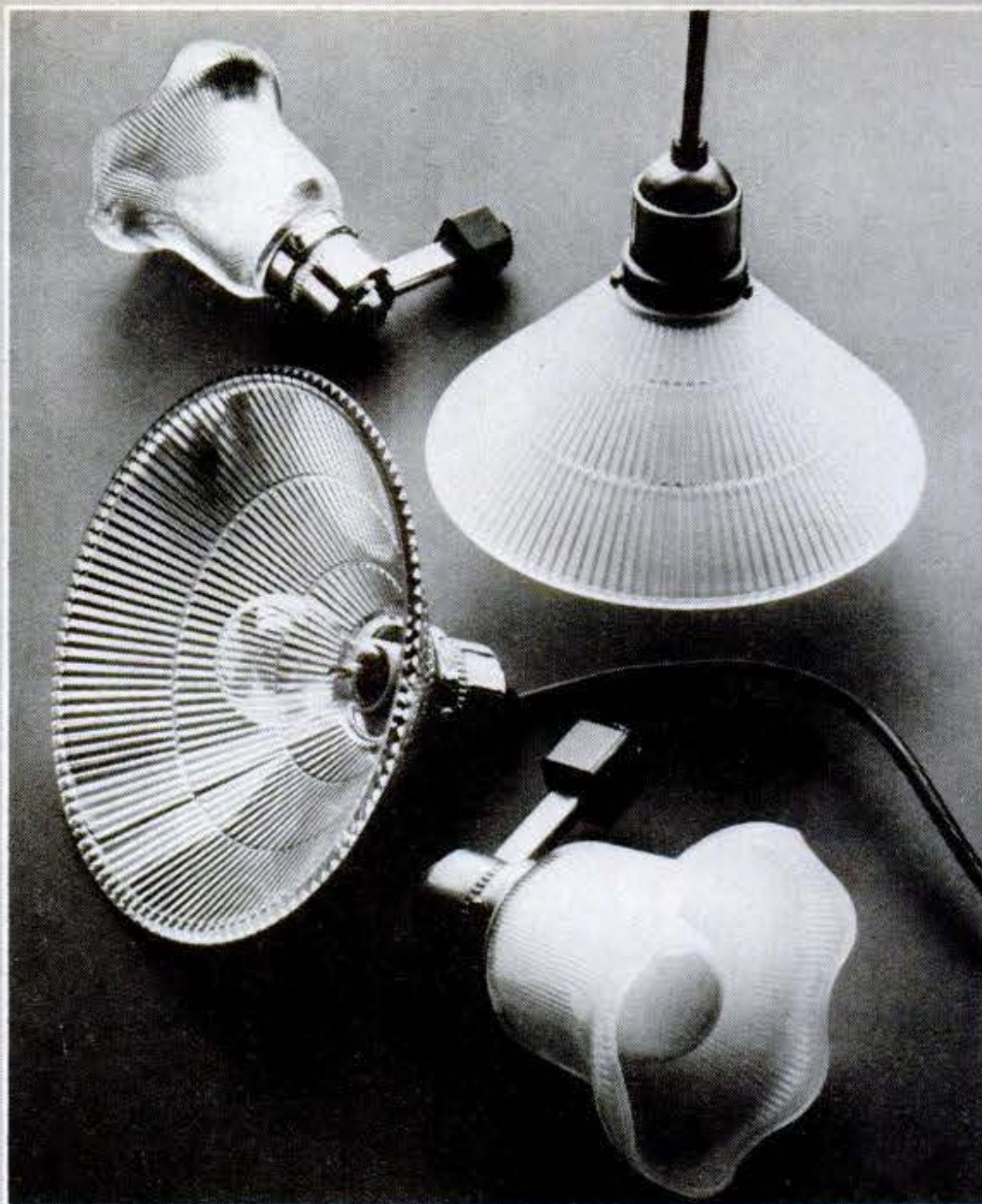
Larger mirrors require three or four 60-W soft-light bulbs in separate diffusers across the top of the mirror. The total light strip should be at least 22 inches wide. The ceiling light (minimum diameter, 12 inches) should have 100- to 120-W total. Remember not to aim fixtures directly at the mirror—you'll produce glare.

For a unique look, you might consider track lighting, especially when refurbishing an existing bathroom. Tracks mounted vertically can frame the mirror with adjustable lights. The plug-in types make installation simple, and newly available fixtures with translucent shades look especially handsome in the bathroom (see photos above).

Another trick to remember in bathroom lighting is bounce light—the bonus light that's reflected from light surfaces such as ceilings or a light-colored vanity. If you are planning a dark color scheme in the bathroom, consider adding a light-colored sink or vanity counter below the mirror to bounce light up for grooming.

A floating soffit, or canopy, is another good source of bounce light. Mounting fluorescents to the inner face of a soffit that's open to the ceiling is one of the most efficient ways to use light—you get the benefit of the light bounced off the ceiling as well as the direct light from the fixture itself.

Bathroom soffits are designed to light the user's face, so



the same maker (right) provide a pleasant diffuse light. Height of the pendant fixture is adjustable with a detachable cord clip, so it can be raised and lowered for different levels of light.

the bottom opening should be covered with a highly diffusing material that will scatter light toward the face. A wide bottom opening—from 14 to 18 inches—also helps illuminate the face.

Fluorescent tubes can be mounted directly to the inner face of the soffit board or to the wall, or both, if two tubes are used. For best light reflection, paint the cavity behind the soffit flat white.

Don't confine the soffit to the space above the mirror. Extending the canopy out over an adjacent toilet will provide a glare-free reading light.

Shower stalls and recessed tubs may also need task lighting. For safety, however, the switch should be out of reach of wet hands, and the light should be mounted in a recessed, vapor-proof housing. (The preceding advice assumes that codes permit shower and tub lighting.) Here, plug-in fluorescents may provide a margin of safety in wet environments over the live, screw-in sockets used for incandescents.

Replacing incandescent fixtures with fluorescents can also save you money. Substituting one 40-W, soft-white fluorescent fixture for four 40-W bulbs, for example, will save about \$130 a year on your electric bill, says GE. One 20-W fluorescent substituted for a 75-W incandescent can save about \$40.

But if you want the bathroom to double as a powder room, be sure you have at least one incandescent fixture. If you have shelves or a long vanity counter, add a small table lamp with a 40-W bulb that you turn on for guests. Or you can put a ceiling- or mirror-mounted fixture on a dimmer. Although there are now dimmers available for fluorescents, they are expensive and have certain wattage limits. It's best to use dimmers to control incandescent fixtures only.

Though these lighting tricks are simple, they can help transform your bathroom, making it surprisingly more pleasant and efficient.

Four new solar-project plans

Easy-to-follow instructions make building these clever money-savers a snap

By CHARLES A. MILLER

Thinking about ways to trim your heating costs? Four low-cost, do-it-yourself plans from the Total Environmental Action Foundation (TEA) could help you achieve that goal. The plans are among the most practical available and include:

Retrotrombe: A Trombe wall made by building a double-glazed structure over an existing south-facing masonry wall. The solar heat absorbed by the masonry is radiated into the house. The masonry wall should have no insulation, and the interior wall covering should be in direct contact with the masonry. The cost of this project is estimated at \$810 (for materials only), though federal and local tax credits could reduce the overall cost of this (and the other projects) considerably.

Thermosiphoning air panel (TAP): A passive solar collector for use on exterior walls of wood-frame structures. A black aluminum absorber panel behind the TAP's single glazing collects solar heat, which enters the house through air-flow channels at the top of the assembly. Cooler room air enters at the bottom. At night, you close built-in vents so house heat doesn't escape. Cost to build this project is \$360.

Sunspace: A sun room designed to provide supplemental heat in daytime. It can be used as an attractive addition, too—a playroom, dining area, or work space, for instance. It uses double glazing to trap warm air, which is blown into the house when the temperature in the sunspace exceeds 80 degrees F. The sunspace should be closed off from the rest of the house at night, and protected from overheating during the hot months of summer by sheltering it from the sun with an opaque covering. Cost to build a sunspace addition is estimated to be \$2,600.

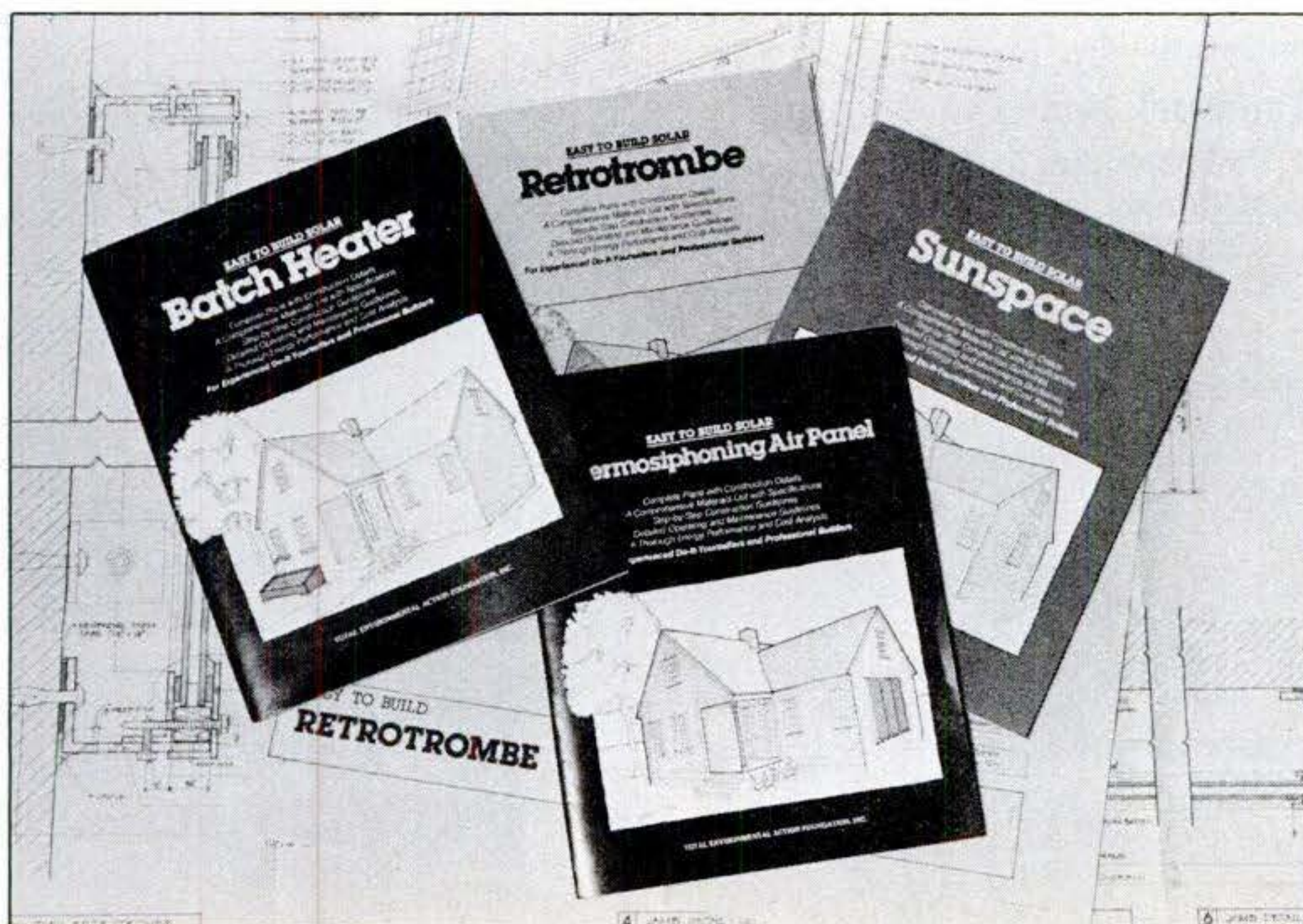
Batch heater: A solar water preheater, used to warm water above its source temperature before it's fed into the regular water heater. It consists of a 30-gallon tank mounted horizontally in a single-glazed insulated box. TEA says cool water can be warmed by 70 degrees or more with this design. The tank must be drained for winter and the water diverted inside the house—the plans detail ways to plumb the system to accomplish this. Cost to build: \$300.

Each set of plans costs \$9.95 and includes well-done construction drawings and booklets showing step-by-step details. Included, too, are tips on operation and maintenance of the projects and a general discussion of energy conservation.

Each booklet contains a pre-construction checklist detailing common-sense measures that are sometimes overlooked, such as:

- Examining the existing energy-saving features of your house and ways to improve them before doing a solar project.
- Knowing local codes and building-permit requirements.
- Making sure the location for your solar project gets enough sunlight for the system to work properly.
- Planning your work schedule and materials delivery to eliminate becoming bogged down by unnecessary delays.
- Ensuring that your home's structure is right for the project.

In addition, each booklet has a bill of materials with each item's estimated cost and a list of tools you'll need. There is, too, a bibliography listing publications on related topics. Write to TEA at Box 29, Harrisville, N.H. 03450. **PS**



Annual savings using projects with various heat sources

City	Project	Oil (\$)	Elec. (\$)	Gas (\$)
Nashville	Sunspace ¹	99	170	54
	Batch heater ²	44	75	24
	TAP ¹	22	37	12
	Retrotrombe ³	77	132	42
Boston	Sunspace ¹	116	199	63
	Batch heater ²	39	67	21
	TAP ¹	29	49	16
	Retrotrombe ³	94	161	52
Denver	Sunspace ¹	231	395	126
	Batch heater ²	51	87	28
	TAP ¹	58	97	32
	Retrotrombe ³	163	279	89
Tucson ⁴	Sunspace ¹	136	233	74
	Batch heater ²	60	103	33
	TAP ¹	34	57	19

¹In well-insulated 1,500-sq.-ft. house.

²For household of four using 65 gallons daily.

³Retrofitted to an uninsulated masonry building; requires exterior summer shading device.

⁴Retrotrombe is not recommended for this climate.

By **JIM DUNNE**
and **JACK KEEBLER**

DRAWINGS BY
RUSSELL VON SAUERS

Servicing GM's A-cars

General Motors' new A-car represents the state of the art in Detroit iron. However, if you've peeled back the hood on any new car recently, you know that it's an intimidating sight. Most car owners figure that servicing these sophisticated vehicles is far beyond their ability. Actually, the reverse may be true. Sure, there are some jobs that require expensive tools or special training, but Detroit's goal is to make its new cars a cinch to service. Most procedures require only hand tools and your car's bible—the factory repair manual.

To give you an idea of how much progress has been made in making servicing easier, we'll focus on four major components of the new A's that you might assume are too tough for a do-it-yourselfer to tackle:

- Throttle-body-injection unit.
- Electronic control module (the on-board computer).
- Power rack-and-pinion gear.
- Automatic transaxle.

The TBI unit

The 2.5-liter (153 cu. in.) engine option on the A-car is equipped with electronic fuel injection [PS, Nov. '82].

The throttle-body-injection (TBI) unit mounts on the intake manifold; the heart of the unit is its injector. Rarely does anything go wrong with this part, but if the injector body started to leak, removal and replacement would be necessary. The procedure is easy.

Before you replace what you believe is a defective injector, however, pull its electrical connections and clean the terminals. That may help. If not, remove the air cleaner. Take off the five Torx-head screws that retain the fuel-pressure-regulation housing. (You'll need a special screwdriver, available at stores such as Sears.) Pry the injector up and out with two screwdrivers, one to form a fulcrum and the other to pry upward on the undercut notch that's just in from the nozzle.

To reinstall, use your hands (see drawing). Make certain the O-rings fit in place and the injector is completely seated.

The black box

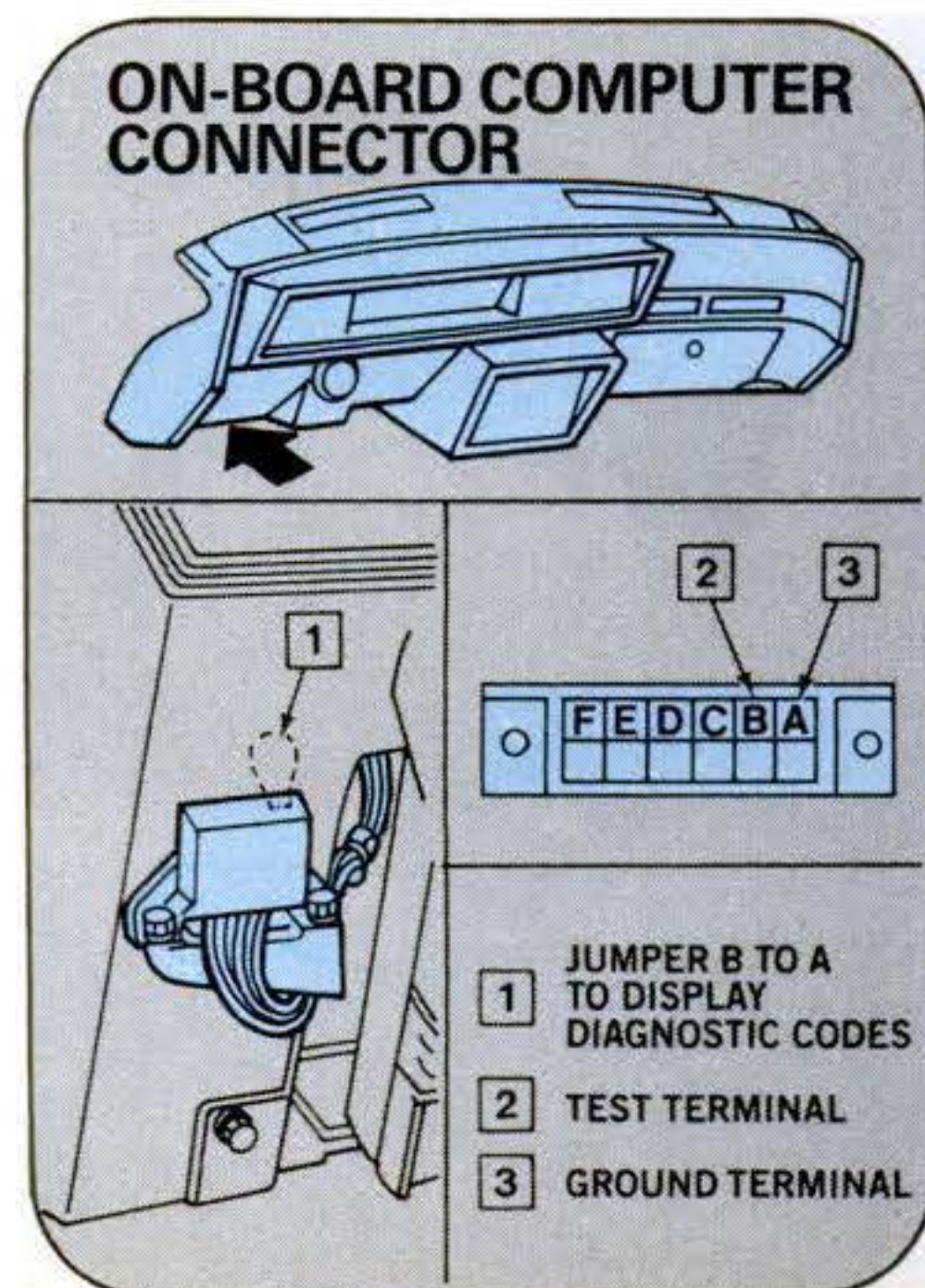
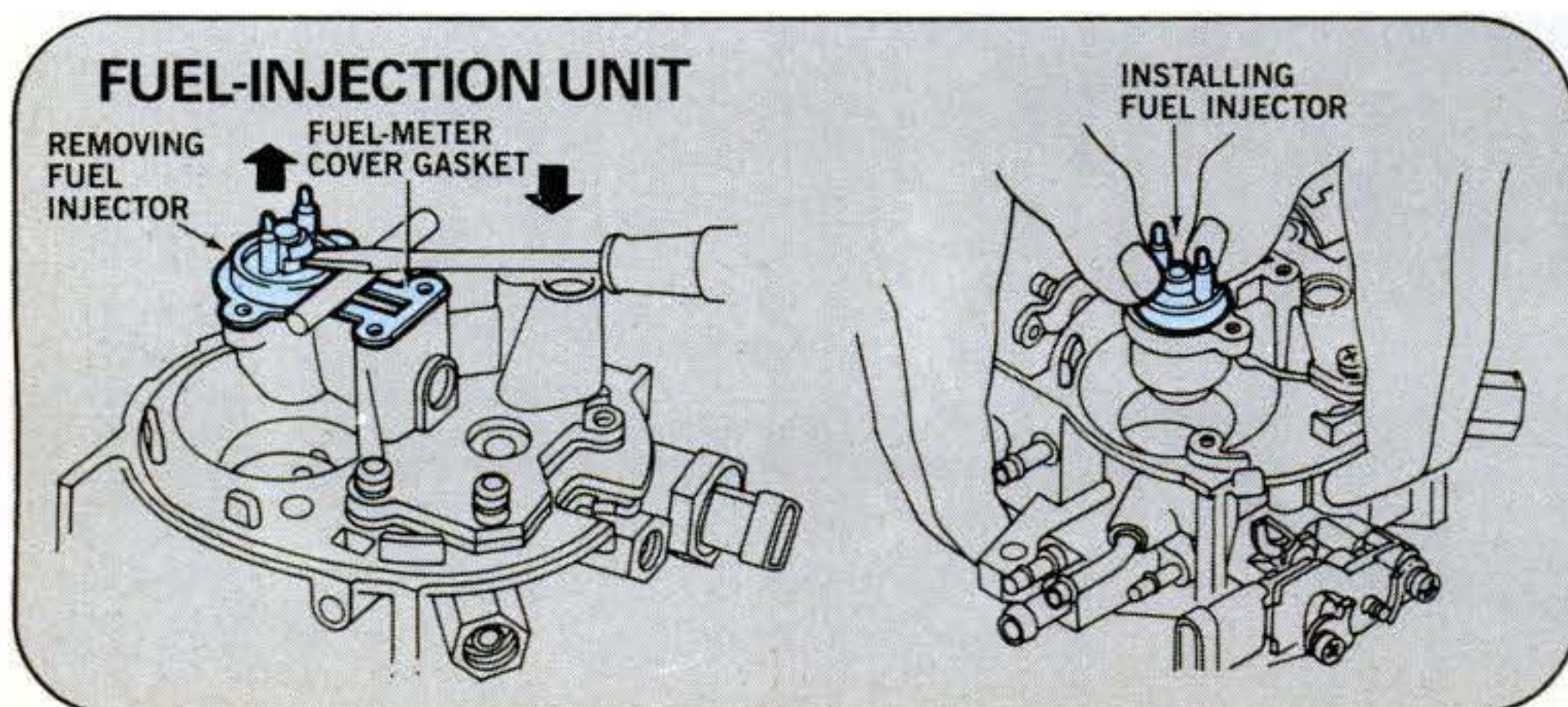
Probably the most feared component in new automobiles is the black box, the on-board computer. But this unit actually has a built-in self-diag-

nosis capability. When there's a problem, the dash CHECK ENGINE light is energized. With this light you can pinpoint the reason for a rough idle, poor performance, or even a no-start.

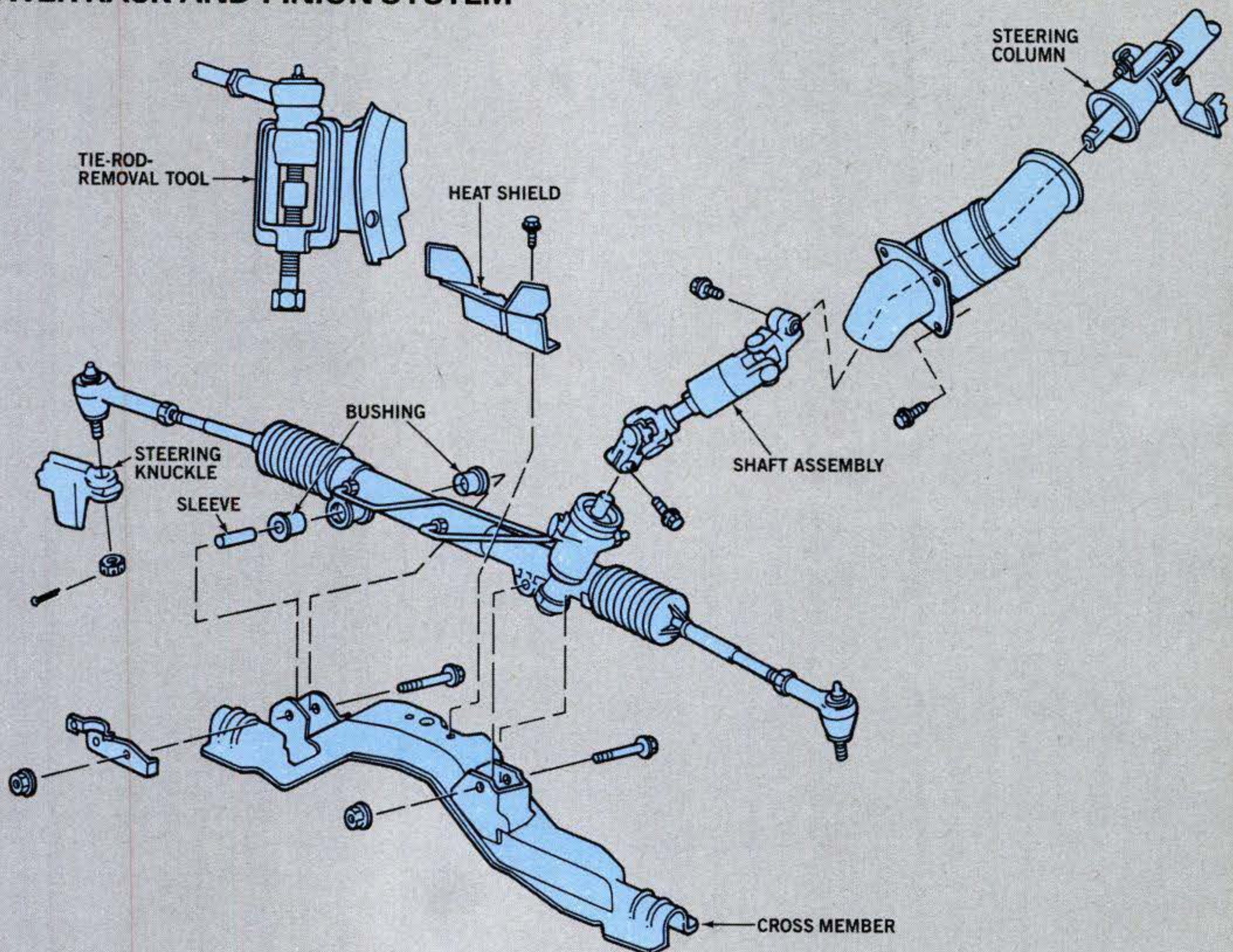
You think there's a long list of special test equipment that taps into this diagnostic system? We went over to GM's Service Development Center and talked to Ron Spies, a senior program developer. Spies showed us how to use a paper clip to tap the system.

(Of course, use extreme caution to ensure the correct connections are made. Refer to your factory manual to avoid reducing your expensive computer to a lump of smoking plastic.)

By shorting the A and B leads on the assembly-line diagnostic-link connector with the clip, he activated the diagnostic system. The CHECK ENGINE light flashed a code. It blinked once and paused, then flashed four more times. The code was thus 14. We



POWER RACK-AND-PINION SYSTEM



scanned the code-14 flow chart in the repair manual, which gives a list of probable troubles. One of the problems listed was a shorted coolant-sensor circuit. Sure enough, a peek under the hood revealed a disconnected coolant-sensor wire.

The steering system

The power rack-and-pinion steering system on the A-cars is a simple design that works well. A control valve directs hydraulic fluid from the belt-driven steering pump to either side of the rack's piston. The integral rack piston converts this pressurized fluid into a linear force that moves the rack (and thus the wheels) to the left or right.

Power-steering units are usually difficult to repair. There are many seals that can wear and eventually leak. Replacing them requires a pro's skill and knowledge.

However, removing the rack yourself could save you a large chunk of the labor charges. You first remove the bolt that clamps the universal shaft to the rack stub shaft. To give yourself some elbow room, remove the air-cleaner assembly. Next, disconnect

the power-steering fluid pipes. Raise the car with a jack and support the front end with jack stands. Remove both front wheels. Then remove the tie-rod ends from the steering knuckles. (Buy the special tie-rod-removal tool, and you'll save yourself a lot of unnecessary grief.) Disconnect the air-management pipe bracket from the cross member. Slide a hydraulic jack under the rear of the engine-support cradle and remove the two rear cradle-mounting bolts. With the hydraulic jack, carefully lower the rear of the cradle by four or five inches. Remove the rack-and-pinion heat shield. Finally, remove the two rack-mount bolts and slide the entire assembly out through the left wheel opening. Now it's time to take the unit to a local repair shop or dealership. Installation is simply the reverse procedure.

The transaxle

"Your automatic transmission needs work." Few words from a mechanic can strike more terror into your heart. You picture yourself telling the family that the ski vacation is canceled—and you'll have to put

that new roof on the garage yourself.

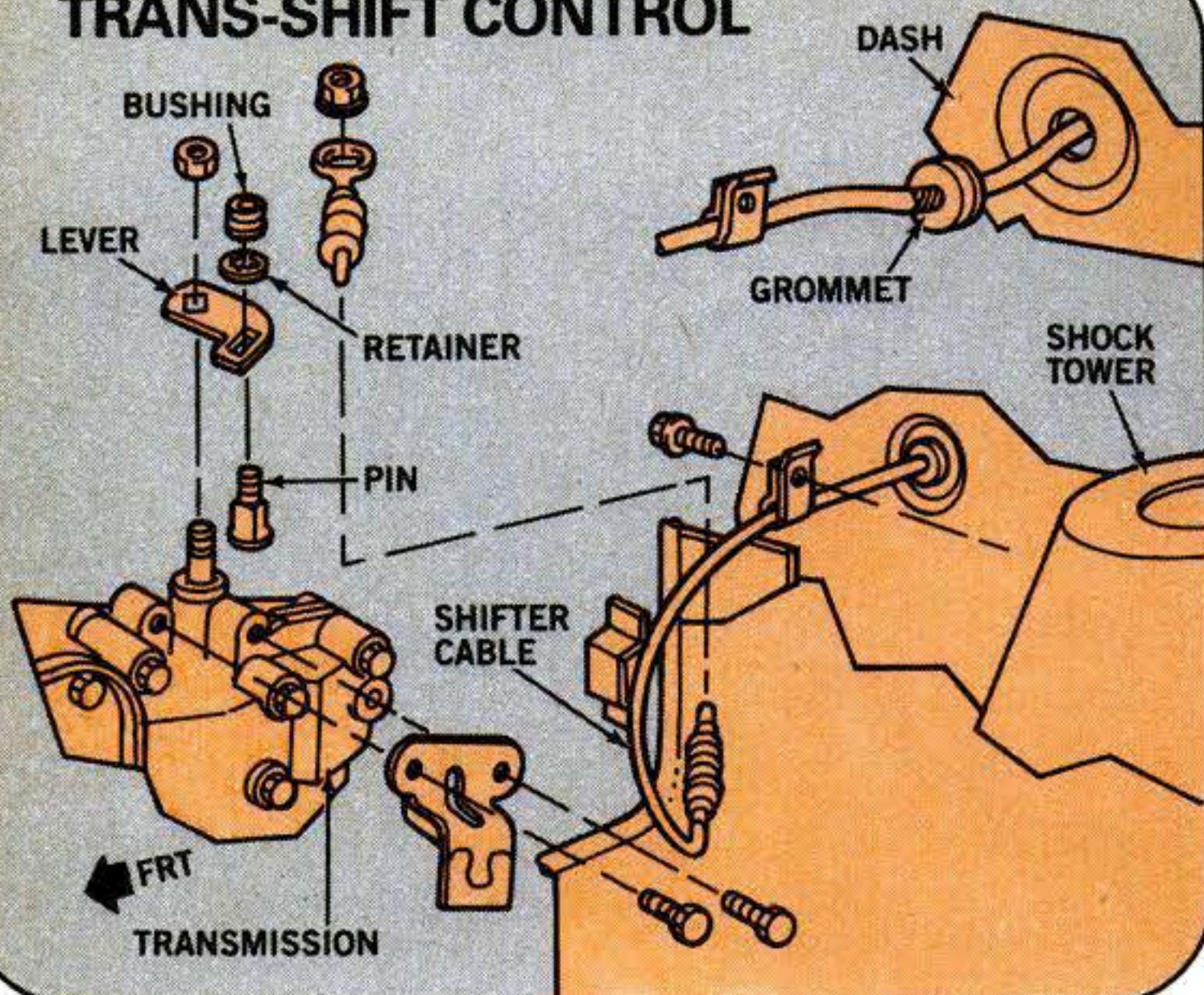
The THM 125C transmission in the A-car consists primarily of a four-element hydraulic torque converter, compound planetary gear set, and complicated dual-sprocket-and-drive-link assembly.

A new development in the C model 125 series improves gas mileage. The torque converter in this unit contains four parts: a pump, turbine, stator, and pressure plate. That last item is not often found in automatic transmissions. Its job is to provide a mechanical (solid) coupling of the engine and transmission (planetary) gears. Earlier automatic transmissions without this feature are much less fuel efficient than manual transmissions because there is some loss of power from slippage at the fluid coupling of the stator and the turbine.

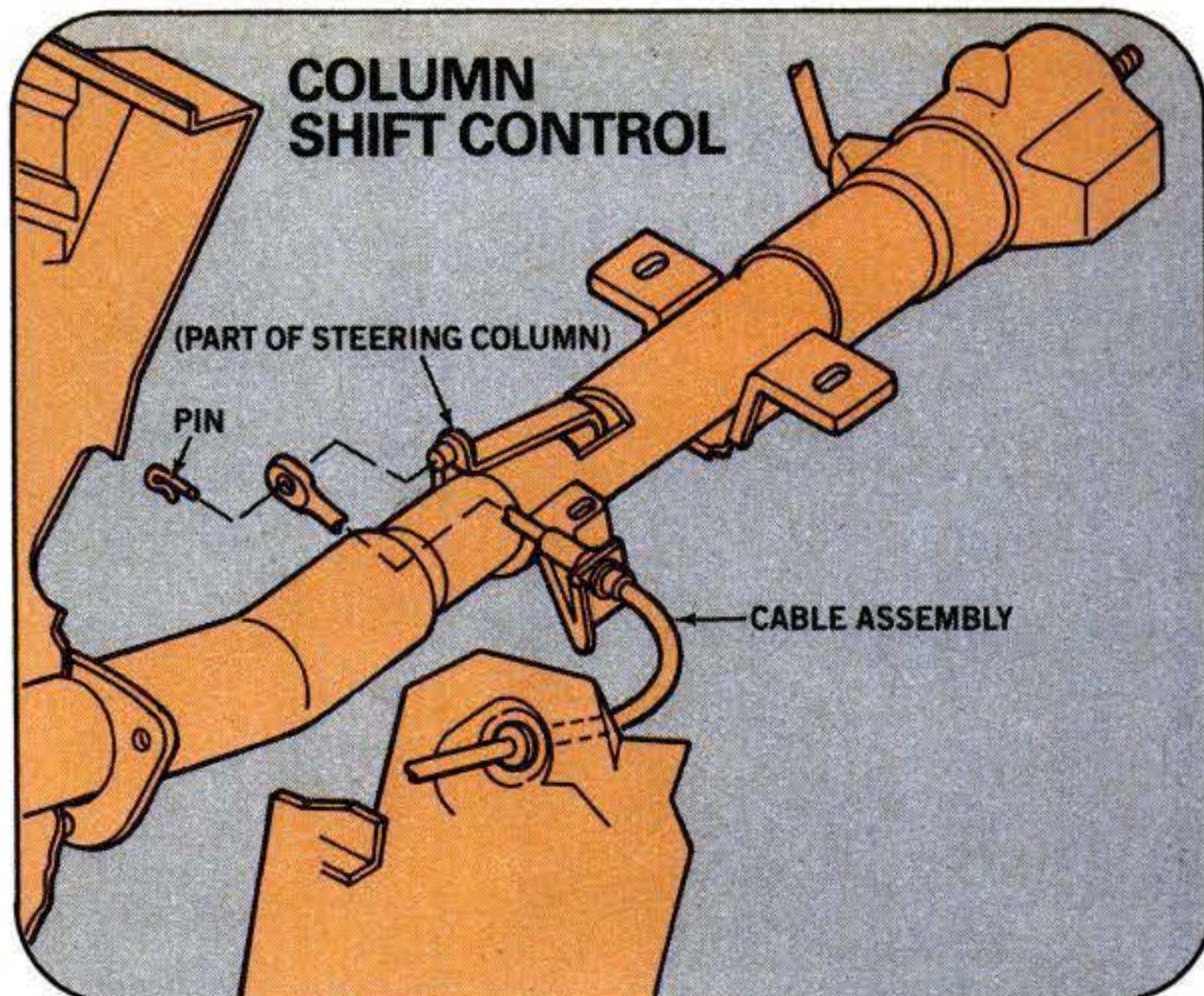
Even this sophisticated new component has important service procedures owners can tackle. If you have serious trouble with the 125C, the best way to protect yourself is to read about your ailing slush box in the transmission-diagnosis and on-car-service sections of the factory repair

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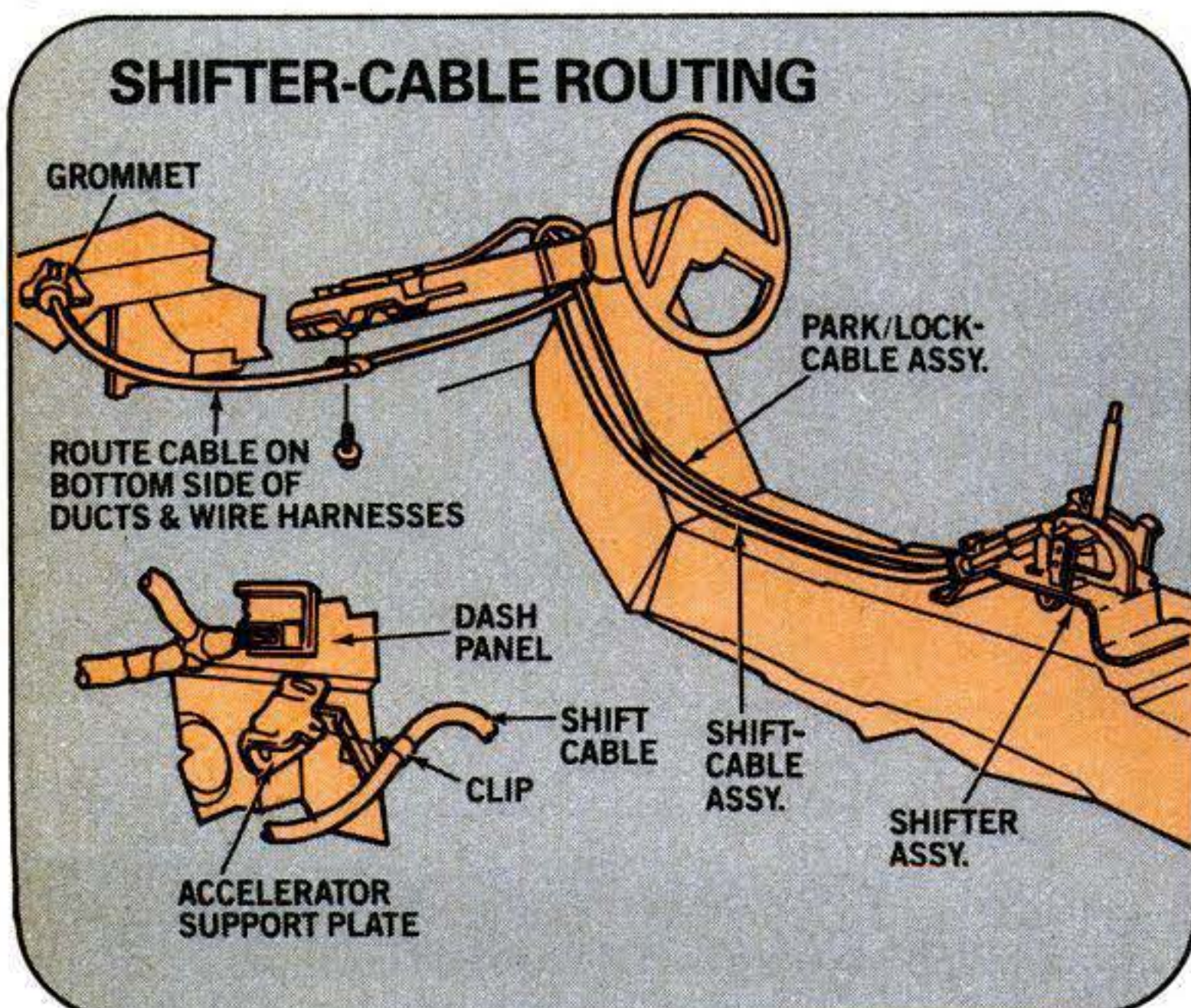
TRANS-SHIFT CONTROL



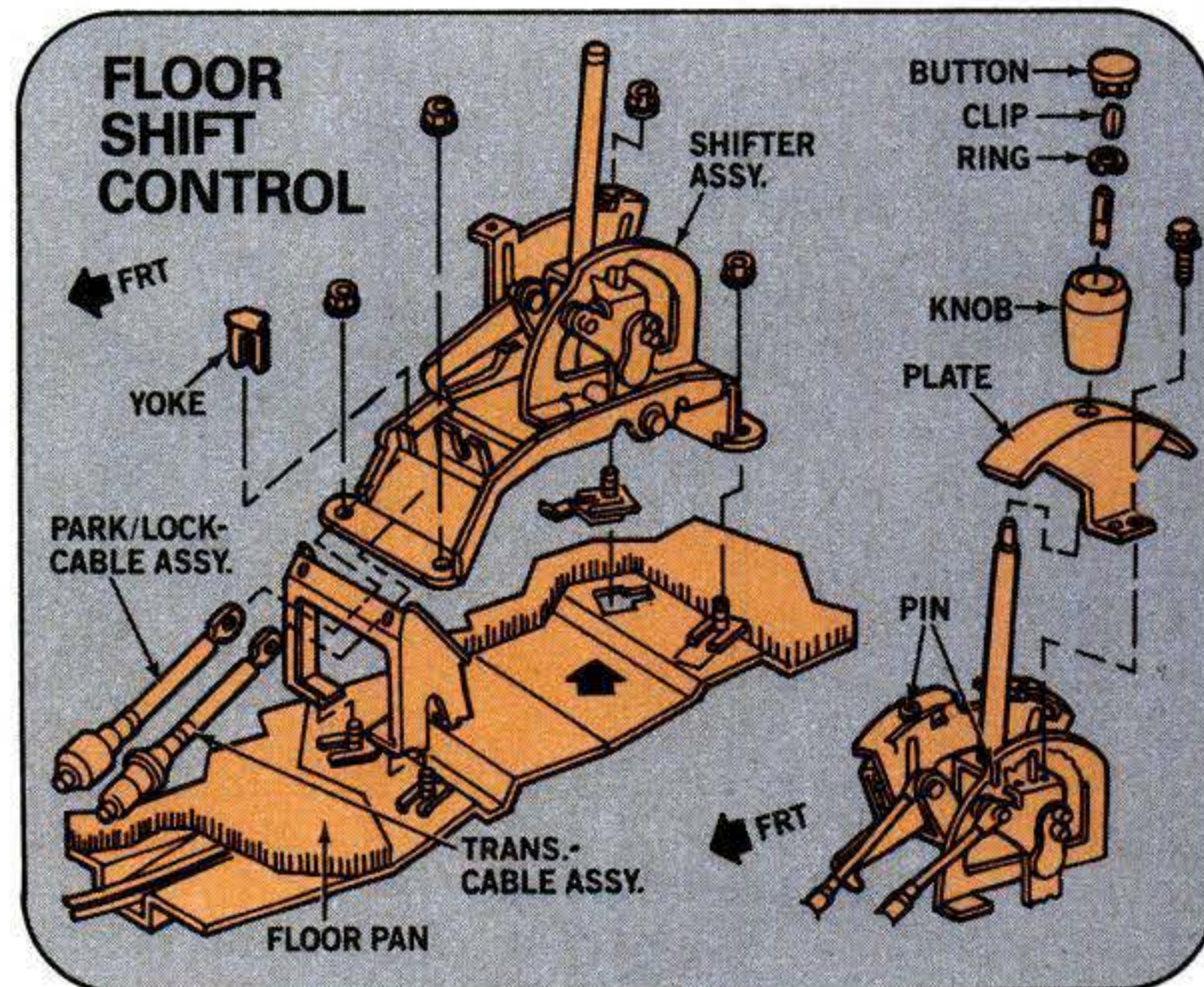
COLUMN SHIFT CONTROL



SHIFTER-CABLE ROUTING



FLOOR SHIFT CONTROL



manual. Flow charts headed by such titles as "Slips—Chatters in 1st," "Shifts 1-3 (Misses 2nd)," and "No Full Throttle Downshift 2-3" help determine the causes of problems. Armed with the manual, you can decide whether you need a pro's help or the problem is an adjustment you can make yourself.

You'll find that quite a few symptoms can be traced to relatively simple problems. Binding or wrongly adjusted linkages can make a healthy transmission sound and act as though it's about to attack your savings account. As you can see from the illustrations, shifting is controlled by a cable. Wrong adjustment can cause an internal transmission leak. That usually leads to clutch or band slip.

To install and adjust the 125C's transmission-control cable, place the shift lever at N (neutral). Then place the transmission lever in neutral. Next, install the cable end on the pin through the transmission lever. Finally, install the cable retaining nut on the pin.

Another important transmission-cable adjustment for the 125C is the park/lock control. This cable is part of the system that makes it impossible to move the transmission out of park when the ignition key is removed. To adjust it, place the column lever in the P (park) position and lock the column with the ignition key. Then place the transmission-control lever in the park detent position. Install the cable-to-shifter mounting bracket. The final step requires you to install the cable to the park/lock pin on the shifter and install the pin. To adjust the length of the park/lock cable, push in the cable's lock button. This may not seem like an important adjustment unless you've once been caught by an ignition key that was difficult or impossible to remove.

The other important cable adjustment is for the throttle valve (T.V.). Many of the symptoms of a wrongly adjusted T.V. cable could make an unscrupulous or uninformed mechanic see big dollar signs. The transmission may not upshift, shifts may be de-

layed, or the bands and clutches may chatter or slip.

Checking the T.V.-cable adjustment requires a line-pressure gauge and a tachometer. First, install the line-pressure gauge and tach. Start the engine and check the line pressure at 1,000 rpm with the selector lever in P. You'll have to refer to the chart in the factory repair manual for the correct line pressure. Then, move the selector to N and run the engine at the same speed. The pressure should remain about the same. If it's 10 psi higher than in park, an adjustment is probably needed. The final step is to increase the rpm to 1,400. Only then should the line pressure increase. Adjustment is merely proper cable installation. On the 125C, you simply depress and hold a metal adjustment tab. Then pull the cable against the cable-bracket slider and release the adjustment tab.

Will Detroit ever make cars maintenance-free? Not likely. But really difficult maintenance jobs may well become rare.

Regular, 1 mg. "tar", 0.2 mg. nicotine
av. per cigarette, FTC Report Dec. '81.

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The pleasure is back.
BARCLAY

99% tar free.

Warning: The Surgeon General Has Determined
That Cigarette Smoking Is Dangerous to Your Health.

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The ultimate sound for cars? **Super-stereo**

It took Delco-GM and Bose three years to design. Now it's an option for '83

By LEN FELDMAN

Author Len Feldman is a prominent writer and consultant for the hi-fi industry, as well as technical consultant to the Electronic Industry Assn.

It was the most mysterious invitation I had ever received. Bose Corporation, maker of hi-fi loudspeakers and other stereo equipment, was inviting several writers in the audio field to its headquarters in Framingham, Mass. But this was not the usual press tour. I was also told that this would only be our first stop—and I'd be gone for at least three days.

A hint of what was ahead came when I learned our other two destinations: Kokomo, Ind., the home of Delco Electronics, and Detroit, Mich., the location of General Motors. The specifics came a few days later in the Bose conference room. It was there that Dr. Amar Bose, an MIT professor and founder of the company, revealed the details of a "secret project" that he

and his engineers had been working on for nearly three years.

"Everyone has always told me that the inside of a car is about the most hostile environment in which to install a stereo-sound system," he said. "While that may be true if you think about road and wind noises, the high absorption of treble sounds, and the less-than-ideal seating positions of the driver and passengers, there's a positive aspect of designing a car stereo system, too. If you could get all the parts to work so that the sound was natural and realistic in a given model car, you could duplicate that sound quality in as many cars of that model as you pleased."

Designing a system for a specific car model requires the cooperation of the auto maker, however. So in 1979 Bose proposed a joint venture with Delco, GM's electronics-manufacturing arm. The result is the Delco-GM/Bose Music System.

"The acoustics, cubic volume, and listener positions are all fixed," added Dr. Bose. "That could lead to a better sound system than is possible in a home music system, where listeners may shift positions, room sizes, and furnishings, and loudspeaker locations vary.

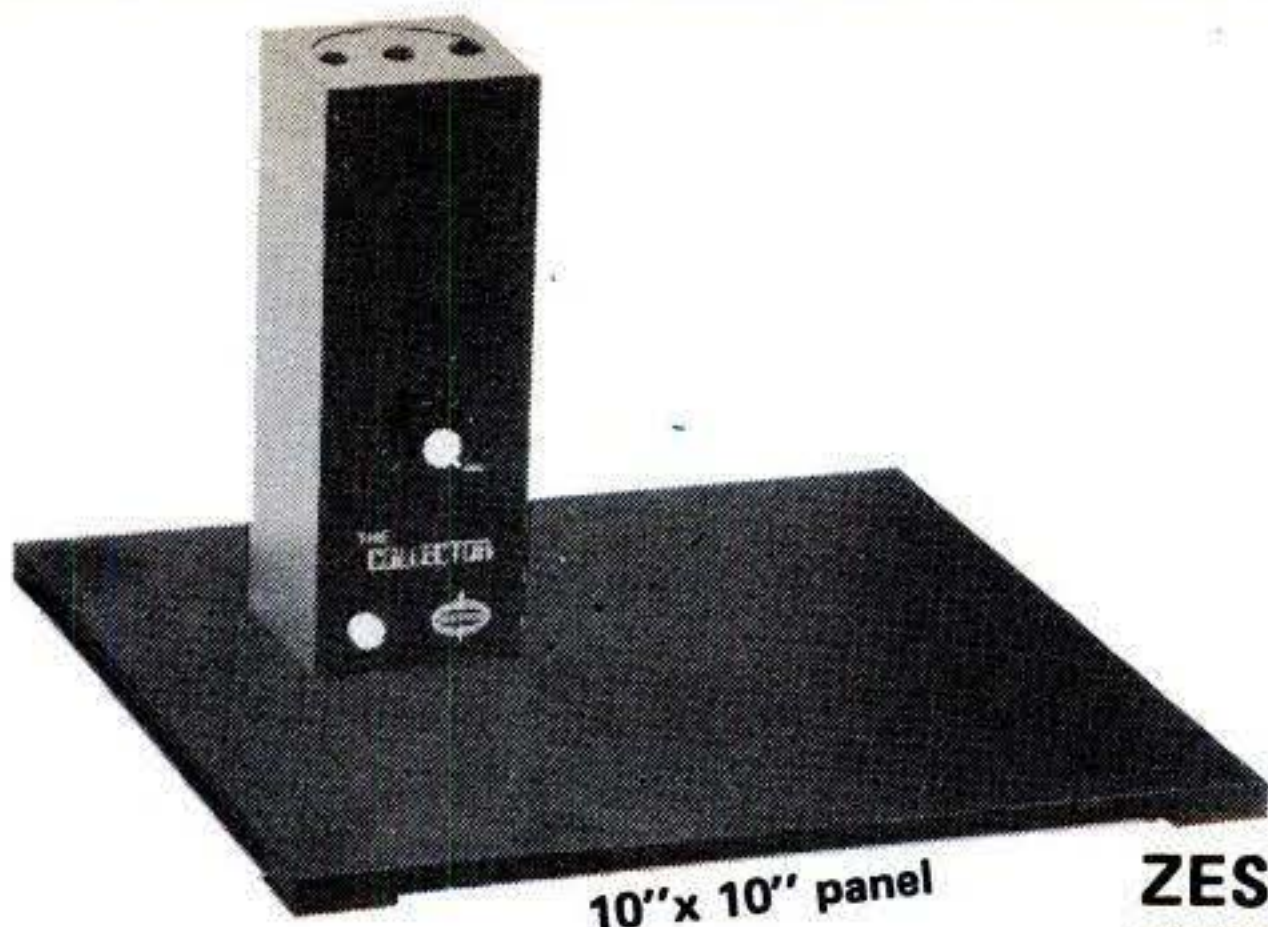
Secret to the incredible sound of the Delco-GM/Bose Music System is separate speaker-amplifier module (above). Each module is acoustically tailored for a specific location in a particular car. Four modules are used in a system.

"Our joint venture," he concluded, "offers the exclusive opportunity to know exactly what tuner, cassette-tape player, and preamplifier will be used with what power amplifier and speakers. But most importantly, it gives us the knowledge of where the listeners will be sitting, and the exact acoustics of the listening environment. The project is truly an engineer's dream."

Was he right? Could a car music system rival the sound and stereo separation of the sophisticated home systems we've become accustomed to hearing?

To find out, I tried three new car models at GM's test track in Detroit: a Seville, Riviera, and Eldorado. The ride in each was superb, but the music was even better. I listened mostly to classical music, although the sampler tape that comes with the system has a bit of everything—from rock to electronically synthesized music. I moved to each passenger position (yes, I did

Continued



THE COLLECTOR

IF YOU WANT CLEAN FRESH AIR OR YOU'VE UNPLUGGED YOUR POPULAR FILTER-FAN UNIT BECAUSE IT DOESN'T WORK, THEN READ ON.

Is your indoor air fresh, clean and alive? Indoor air pollution is becoming a national health hazard. Energy efficient airtight buildings are stifled with stale polluted air which includes smoke, dust, pollen, viruses, and bacteria. Most of these pollutants are so small (under 5 micros) that they are not effectively removed by common small filter-fan units. Scientific tests show that these noisy inefficient units which emit chemical "citrus" odors are more like toys, and are no match for high-powered ionizers in thoroughly cleaning the air we breathe.

ANOTHER IMPORTANT DIFFERENCE

You know how good and vibrant the air feels right after a rain storm with that crisp, fresh smell? Just like in the mountains, near a waterfall or at the ocean. That clean, alive fresh air is rich in something important that is missing or greatly depleted in our urban and indoor air. The missing element is negative ions, nature's own air cleaners. *Scientists claim that these amazing active ions are of great benefit to you and can actually make you feel alive, revitalized and alert while relieving depression, headaches and allergies. Negative ions promote sound sleep, learning and healing and even make plants grow better. In addition, hospitals use ionizers in burn units to destroy bacteria and reduce pain.*

Filter fan units do not emit negative ions. The COLLECTOR, by Zestron, creates trillions of these beneficial ions every second, while giving you the best performance, value and technology in air cleaning.

THE ZESTRON BREAKTHROUGH!

Most ionizers clean your air but leave an untidy deposit of pollutants on room and furniture surfaces near the ionizer. The COLLECTOR by Zestron takes ion technology a giant step forward by giving you superpowered ion output while depositing pollutants from your air on the collector panel. This easy to clean panel features a scientifically formulated surface that electrostatically attracts the vast majority of airborne pollutants to it rather than to the floor or walls near the ionizer.

FRESH AIR BREAKTHROUGH!

ZESTRON, THE LEADER IN ION TECHNOLOGY, ANNOUNCES SUPER-ION OUTPUT IN A BIPOLAR ELECTROSTATIC PRECIPITATOR. "THE COLLECTOR" COMBINES SPACE AGE TECHNOLOGY WITH TRUE VALUE AND PERFORMANCE TO IONIZE AND CLEAN YOUR INDOOR AIR OF HARMFUL, POLLUTANTS BETTER THAN ANY OTHER IONIZER.

ADJUSTABLE OUTPUT-DETACHABLE COLLECTOR

Some people prefer fewer ions at night. The COLLECTOR is the only adjustable bipolar ionizer that allows you to set the ion level to your personal preference. The detachable COLLECTOR allows you to place it where you want to protect desired surfaces and facilitate cleaning. The scientifically formulated surface instantly wipes clean unlike other bipolar ionizers whose porous surfaces absorb odors and unsightly grime.

AMAZING DEMONSTRATION!

Unplug your COLLECTOR and place a facial tissue on top of the collector panel, then place the ionizer unit and an ash tray on top of the tissue. Place a lit cigarette in the ash tray and watch the smoke rise into the air. Now plug it in, and amaze yourself and friends as the smoke barely rises above the ashtray and then nose-dives into and is absorbed by the tissue before it can enter the room air. This air cleaning is accomplished entirely electronically with no moving parts! The COLLECTOR by Zestron is the only ionizer on the market that cleans the air powerfully enough to accomplish this test.

SUPERPOWER OUTPUT

The COLLECTOR by Zestron is the only bipolar collecting ionizer with superpower output. The thoroughness and speed of air cleaning increases with more ion output, and Zestron ionizers give you the highest output (without detectable ozone). Check the comparison chart below. Don't buy any ionizer not stating output using the industry standard of ions/cc/sec. at one meter.

ADVERTISED IONIZER OUTPUT (1 m.) COLLECTOR ions/cc/sec.		
The COLLECTOR	1,200,000	YES
By Zestron		
JSA Bubble	???	YES
Aspen	???	YES
Orbit	???	YES
AirCarell	236,000	YES
Ion Fountain	540,000	NO
Ion Cloud	350,000	NO
Ionosphere	350,000	NO
Modulian	75,000	NO
Ion Breeze	???	NO

FREE ION DETECTOR

A FREE remote ion detector comes with each ZESTRON to verify and compare output. When you place the detector next to a ZESTRON and a competitive unit, you will see greatly reduced or no output from the competitive unit!

SILICON VALLEY TECHNOLOGY

The COLLECTOR, incorporating years of high reliability design experience, is built in the heart of Silicon Valley, USA, using quality parts operating under low stress. It is designed to give you space age performance and years of trouble free service. The COLLECTOR operates anywhere in your home or office on regular current for pennies a month. It has no moving parts and nothing to wear out or replace.

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Don't you, your family and friends, deserve the healthy clean fresh air that Zestron ionizers have brought to thousands of satisfied users? Users write:

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"I haven't taken the top off my nasal decongestant spray since using your product. I was previously a chronic user." G.S. - SD.

When you use your COLLECTOR, you'll quickly feel the difference it makes and smell the freshness in your air. You'll actually see the elimination of smoke and dust in your air!

SATISFACTION GUARANTEED

Order a COLLECTOR now and try it in your home or office risk free for 30 days. You will probably want more units, but if for any reason you are not satisfied, return the unit for a prompt and courteous full refund including your return postage. The COLLECTOR has a full one-year warranty on both parts and labor, excluding abuse.

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Super-stereo

[Continued]

stop the car first), carefully listening for stereo separation. The system really works—all passengers get true stereo at once.

But the real revelation is the sound. It's as good as or better than the best

home systems I've heard. The car's interior, which began as an acoustical nightmare, has been transformed into a controllable "listening room." The results are fantastic.

The most obvious question after lis-

tening: How did they do it? The answer to that came from Joe Veranth, chief designer for Bose.

Balancing act

"The first step in the design, after ensuring that the car's interior was free of unacceptable resonances," Veranth told me, "was the problem of speaker placement." When the speakers are placed in the most "convenient" spot (as is often done with a retrofit stereo system), the driver hears mostly the sounds from the left channel while the front passenger hears mostly the right. "A balance control can't provide proper stereo balance for both listeners at the same time," Veranth added.

The solution required a great many acoustical measurements, modeling, trial and error—and a manikin named "Morgan." Equipped with a pair of sensitive microphones for ears, this electronic listener enabled Bose engineers to determine the acoustic characteristics of individual vehicles.

Sound picked up by the instrumentation microphones in Morgan's ears was processed through a digital computer, then studied by a Bose-developed computer program called Interval (Interpretive Visual Analysis Language). Result: separate high-performance speaker-amplifier modules for each position in the car.

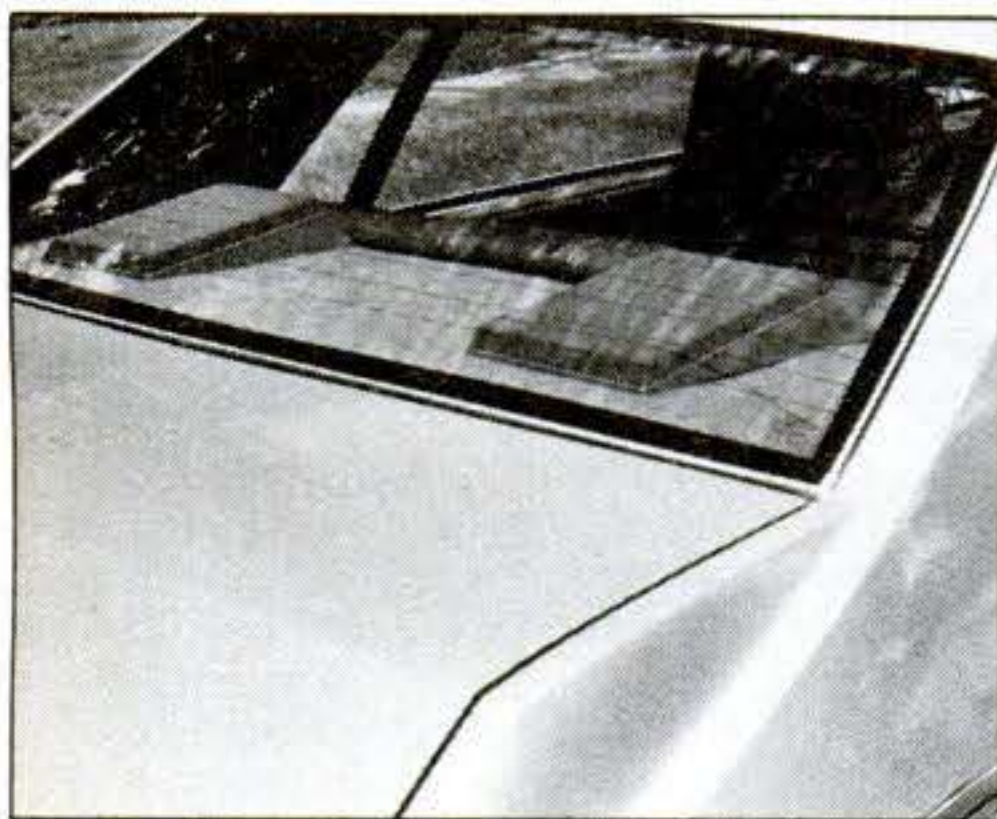
The placement and directional characteristics of the speaker modules were chosen so a listener is closer to one speaker, but more directly on the radiation axis of the other speaker (see drawing).

"It means the level of sound from each channel is equal for both the left- and right-side listener," said Veranth. "The same arrangement is used for the rear modules [four amp-speaker modules are used in each system]. This precise speaker placement means a left-to-right balance control is not required."

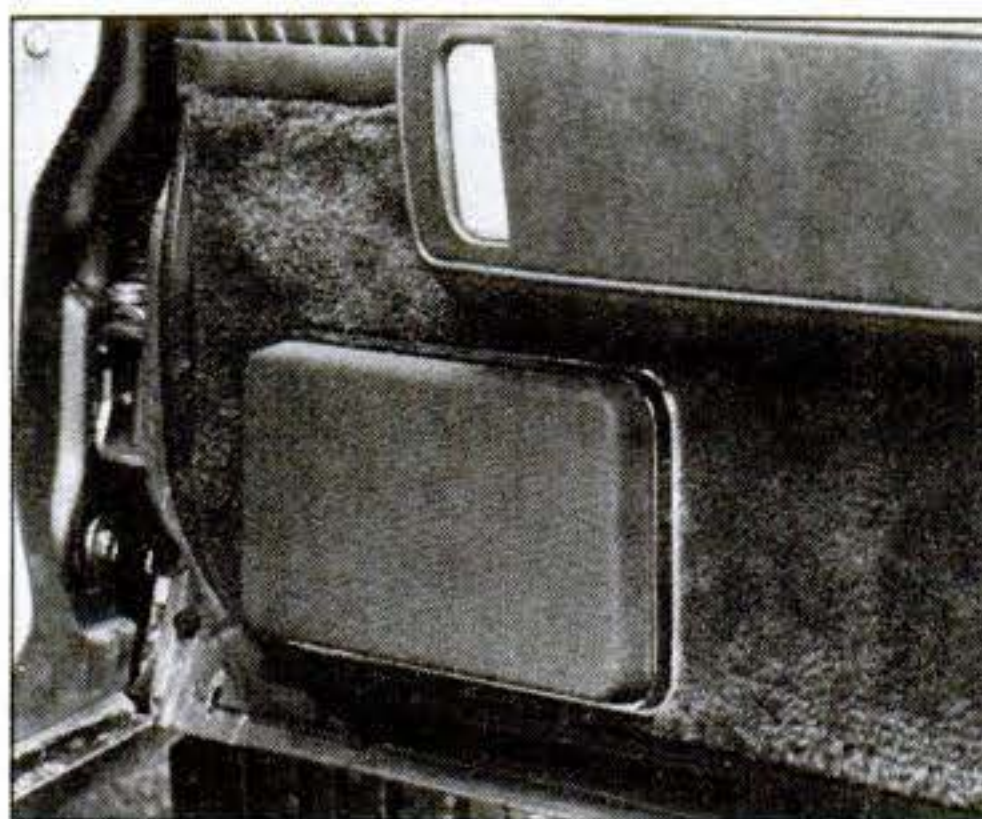
To determine whether a speaker enclosure would be needed, identical speaker systems were mounted with and without enclosures. If the door panel alone would act as an enclosure, there would be little difference in sound and a separate enclosure would not be necessary. But after the test, it was obvious that specially designed speaker enclosures could improve the system substantially.

In a compact car, for example, it would take 30 times more amplifier power (at 50 Hz) to get the same bass

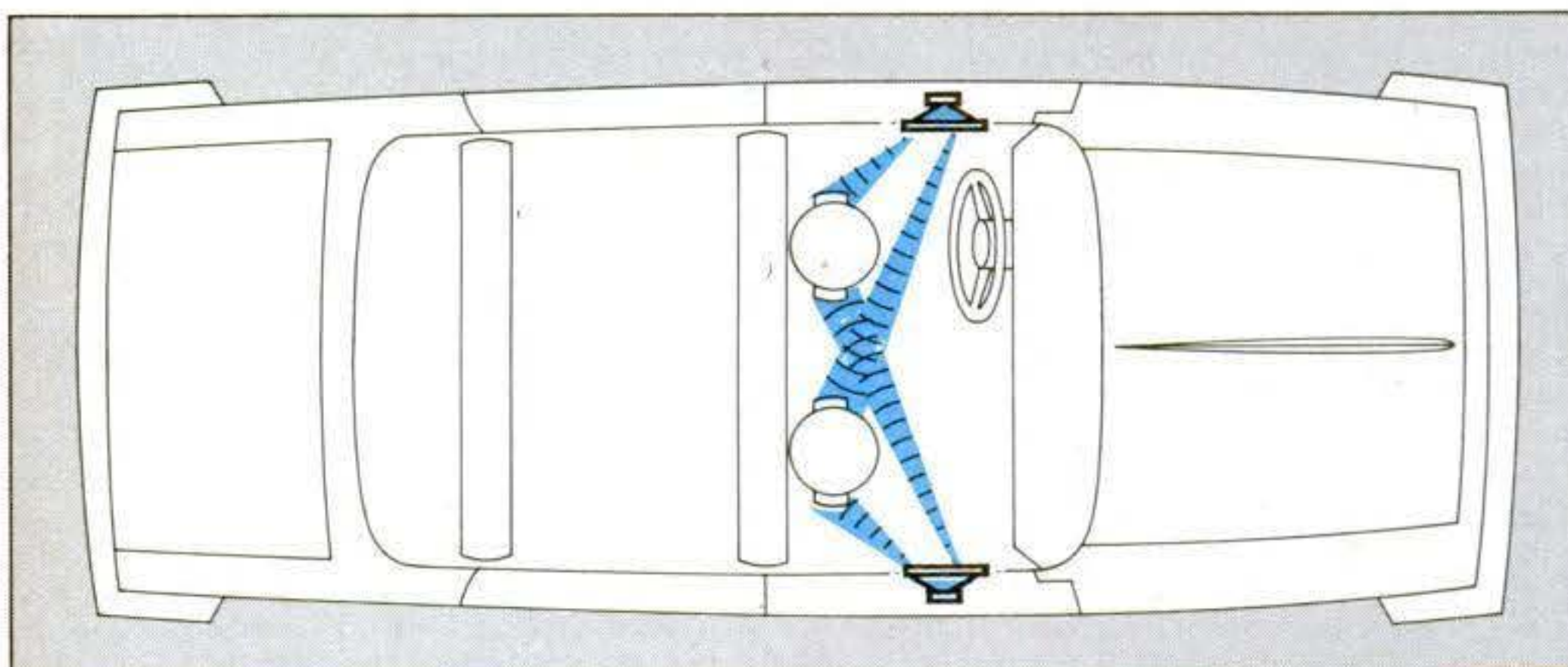
Continued



In-dash system contains a tape player and AM-FM tuner. Only a front-to-back balance control is used. Rear modules on



back deck are aimed at the back window and use it as a sound reflector. Front modules are in the bottom of door panels.



Left and right channels seem balanced to all listeners due to directional characteristics of the modules. Module on the left side of the car is aimed at the listener on

the right; the right module is aimed at the left listener. The same technique is used in the rear speaker modules (not shown). Left-right balance control isn't needed.



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It's true there aren't many companies that offer full-length courses in subjects other than reading and arithmetic, and what is offered seems to be drills, tests, games, or simulations. What you really want is a course that covers the subject with, say, 16 full-length lessons called tutorial programs, where you interact with an expert programmer backed by a staff of experts. That's exactly what we have.

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Is there something wrong with our software? Well, we don't ask you to enter your name so we can drop it into some later text. We don't ask you to type in your answer and refuse to accept it if it's not spelled just right. And, we don't branch around a lot when you make an error. Our programs simply let you know if you're wrong by proceeding only when you select the right multiple-choice answer.

This proven learning-by-positive-reinforcement method lets you proceed quickly and smoothly through the programs, without a lot of cute tricks. But, if you're a devoted computerist or game freak you may be disappointed at the lack of motion in most of the pictures, or our special visual effects. We have some dandies, like the mushroom cloud that rises over Hiroshima in our History series, but your learning is not distracted by needless special effects.

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You'll need your Atari 400 or 800, and the Atari Cassette recorder. And to present the Talk & Teach programs you need the Educational System Master cartridge: it's \$25 from us, if you don't have one.

We say these courses, which are recorded one program per side of C20 to C30 (half hour) cassettes, are the equivalent of a chapter, or perhaps an hours lecture. We've been told that by studying our Economics or Psychology course, a student could pass a secondary or college test for credit. Many who have such credits never learned all that's in these courses. And while some of our courses have 1980 copyrights, most are 1981 and 1982. In U.S. History, for example, you'll learn about America's foreign policy during the

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Super-stereo

[Continued]

output without the enclosure. But the enclosure offers many other benefits besides better bass. It guarantees consistency from one unit to the next, and it physically protects the speaker from hazards such as water inside doors or objects tossed into the trunk.

Perhaps the greatest benefit of all, however, is the opportunity to include more-complex acoustical elements in the design. A carefully tuned port allows greater output without distortion by decreasing required speaker-cone motion for a given sound level. And an equalization circuit boosts some frequencies while attenuating others. The strategy here was to carefully measure the response of the system within the car, then apply active equalization to remove the problems caused by the car's acoustics.

Then there were the "little" problems: The tuner had to be matched to the antenna. The loudness control could be optimized only with the knowledge of what sound-pressure level will be created by a given audio signal. Overload-protection circuitry had to be tailored to the maximum output of the power amplifiers. The special digital circuitry in the power amplifiers couldn't interfere with tuner performance.

And finally, after all of these preliminary design problems were solved, there were other practical ones that popped up. Frequency response changed with directional characteristics of the speakers. That meant final speaker locations had to be adjusted again after equalization was completed. Selection of grille material to match upholstery required yet another round of equalization.

Even the wiring harness in the car caused performance changes that had to be evaluated before freezing the final design.

And now you can buy it

After years of work, the Delco-GM/Bose Music System is complete. Delco's Electronically Tuned Receiver with built-in cassette player mounts in the dashboard. Two speaker modules are installed in the lower section of the front doors, the remaining two are installed in the rear package shelf. Each module contains three separate components: a reflex enclosure specifically designed for each car model, a helical voice coil wide-range speaker driver, and a 25-watt "two-state modulation" amplifier (see box). The characteristics of each amplifier

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are specifically matched to the individual car model and even to the speaker location within the car.

As you might guess, this system won't be available for the Chevy Chevette. For 1983, it will be available as an option at the time of purchase in the Cadillac Seville and Eldorado, Buick Riviera, Oldsmobile Toronado, and Chevrolet Corvette only. It's possible that eventually the system will be designed for other GM models. Obviously, since each system is customized for the model car in which it is installed, it won't be possible to add the unit to any other.

Price? The Delco-GM/Bose Music System is \$895—not bad for the finest sound system ever to hit the road. **P5**

Two-state amp

While Delco's Electronically Tuned Receiver unit has several outstanding features, I was most intrigued by the unusual power amplifiers used in each of the modules. Mounted within the individual enclosures, the amplifiers had to be small in size, despite the 25-watt power-output requirement. Furthermore, correct car-assembly practice required that no direct "heat sinking" to the car body itself be used to cool the amplifier.

Known as two-state amplifiers, the amplifiers in these systems operate by switching very rapidly between two "states," with the output transistors either fully on or completely non-conducting. With the transistor fully on, current flows out to the speaker load but no voltage appears across the transistor; no power is dissipated within the transistor itself. When the transistor is off, voltage appears across the transistor but no current flows from it; so again no power is dissipated. While this description fits earlier so-called switching or Class D amplifiers, in this design a signal (negative feedback) is used to ensure flat response and low distortion, just as in conventional high-fidelity solid-state amplifiers. The on-and-off switching in a two-state amplifier is essentially digital in nature.

In addition to power amplification, the active equalization circuits included with the amplifier provide the processing of the audio signal needed to match the acoustical requirements of the particular location within the car. The signal-processing circuits are actually different between the front and rear amplifiers.—L. F.

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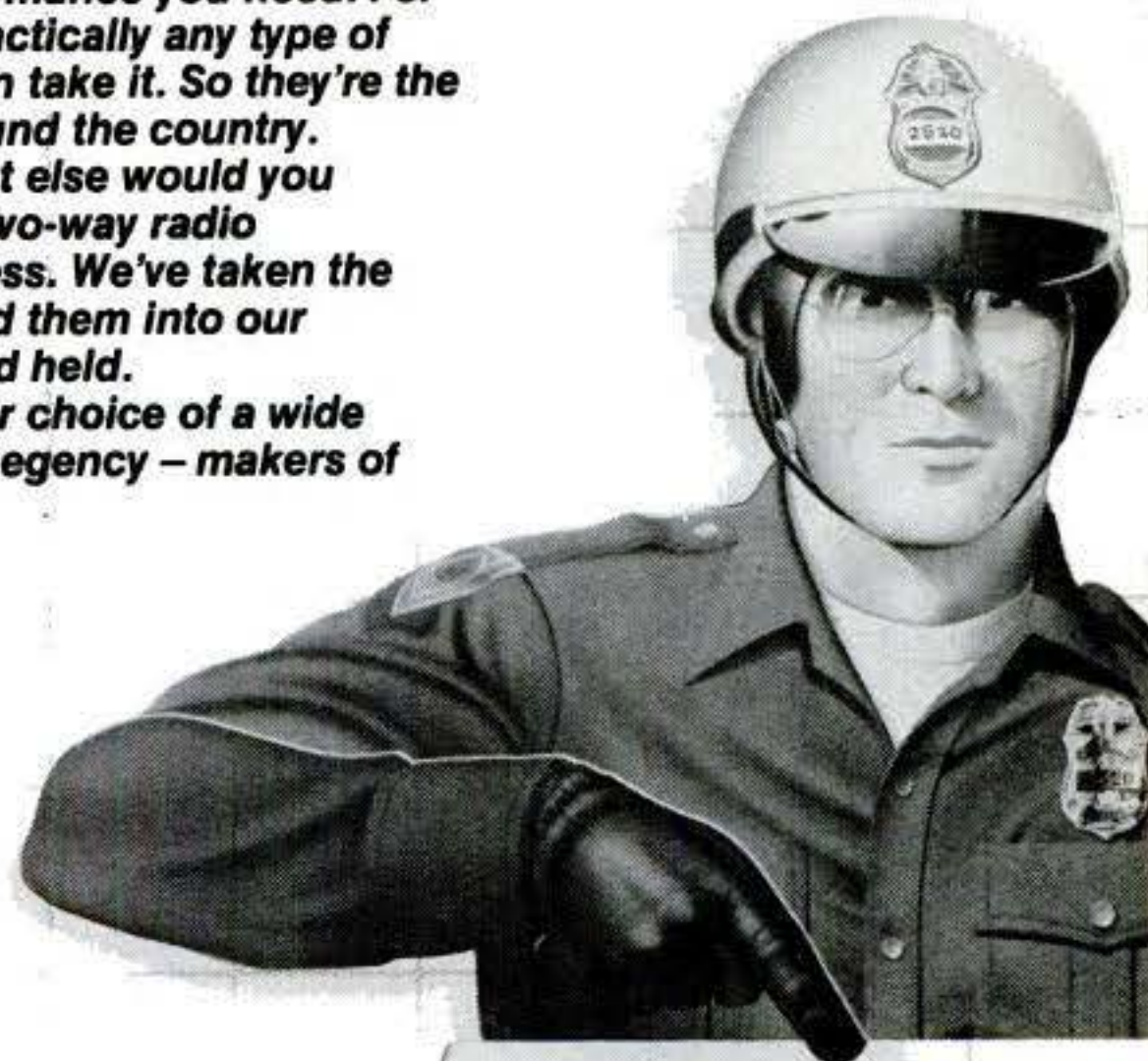
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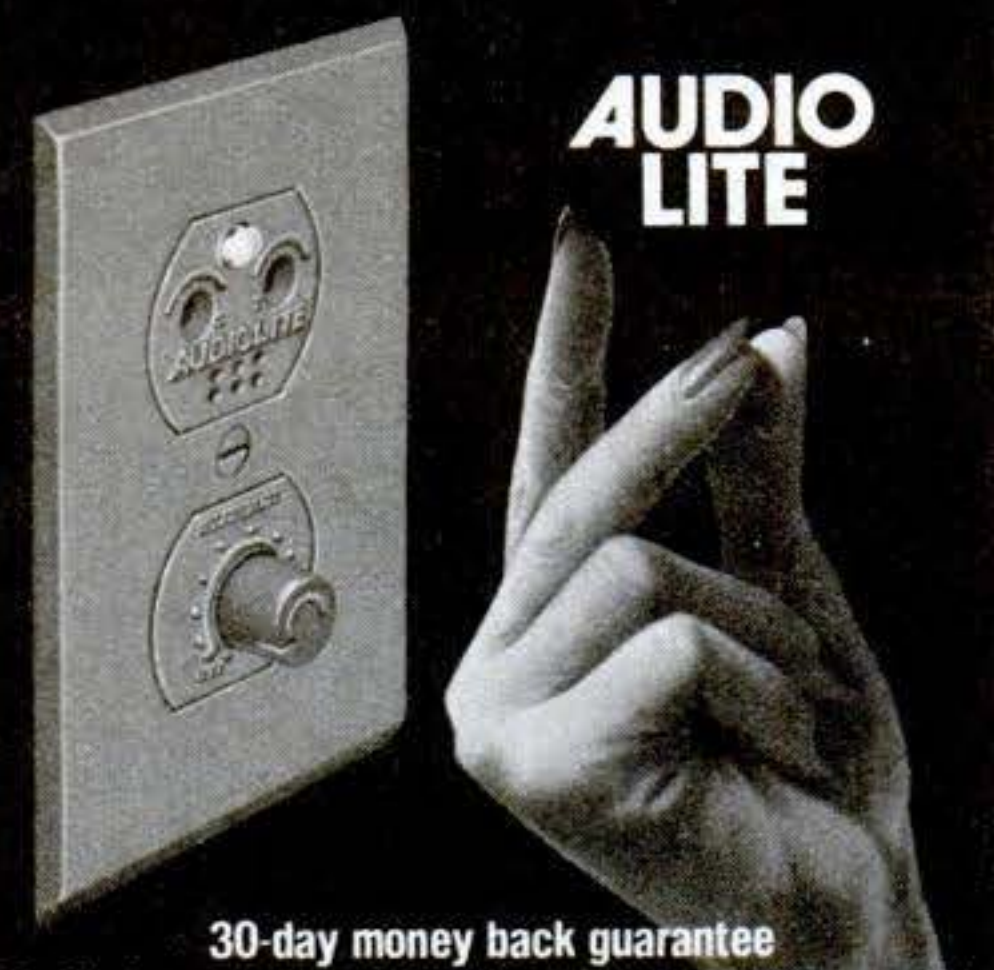
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BITS & BYTES

By WILLIAM J. HAWKINS

CP/M gets graphics

I've been using a CP/M-based personal computer for years. It means my system is completely compatible with thousands of professionally written programs. For most purposes, that's great. But when it comes to graphics—producing pictures—my kids and their crayons get better results.

There are lots of computers capable of producing excellent graphic images: inexpensive models such as ones from Atari, TI, Commodore, and Apple; and some of the newer, more elaborate machines from Hewlett Packard and Zenith. But for the bulk of CP/M-based personal computers, you'll draw blood before you draw a pie chart.

Now that's changed, with a program called Graftalk written by the Redding Group for distribution by Lifeboat Associates (1651 Third Ave., New York, N.Y. 10028). It's a CP/M program that takes raw data and converts them into color graphics: Pie, bar, or line charts are instantly produced for easy interpretation of numerical data.

The Graftalk program comes close to being a new language. Extremely simple commands can be given to produce a rather complicated chart: Type **PIE** as a command and you've got a pie chart. Change your command to **BAR** or **PLOT**, and the graphics for those displays come up just as easily. (The charts here show how it's done. The commands you give are at the top of the screen. These are the actual results from an H-P plotter.)

The numbers it uses can come from the keyboard or they can come from files of data saved on the disc. These files could have been created by other outside programs. If you've used a spread-sheet program to work out expenses, for instance, the numbers can be used by Graftalk to

graphically illustrate your downward slide to the poorhouse. All scaling—to make the highest and lowest numbers displayable on the chart—is done automatically.

Graftalk reserves a number of commands for changing the resultant graph in some way. You can add a heading, specify shaded sections, emphasize a particular area (pull out a slice of the pie to draw attention to it, for example), and have legends automatically placed on the drawing. There's even a joy-stick mode for placing text anywhere on the screen with a paddle control.

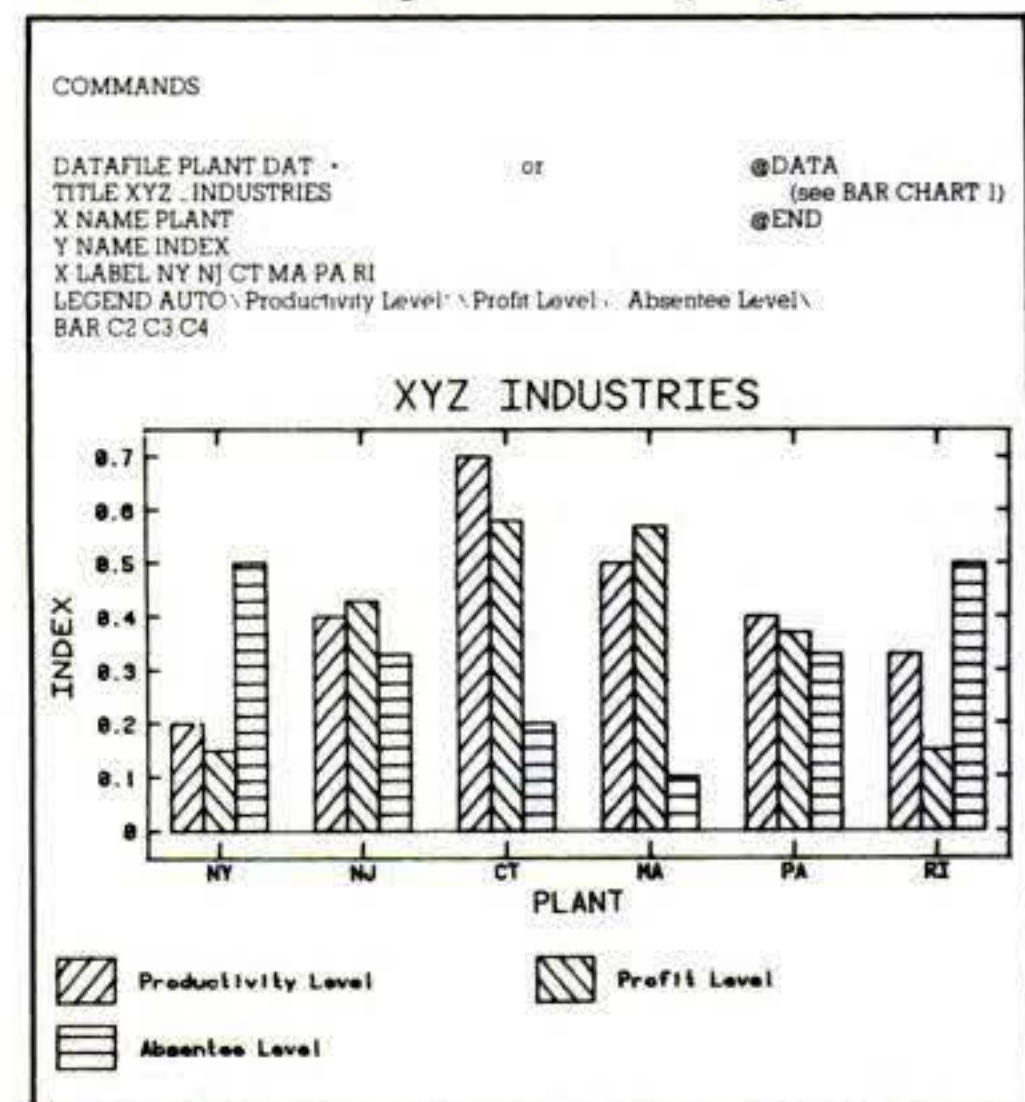
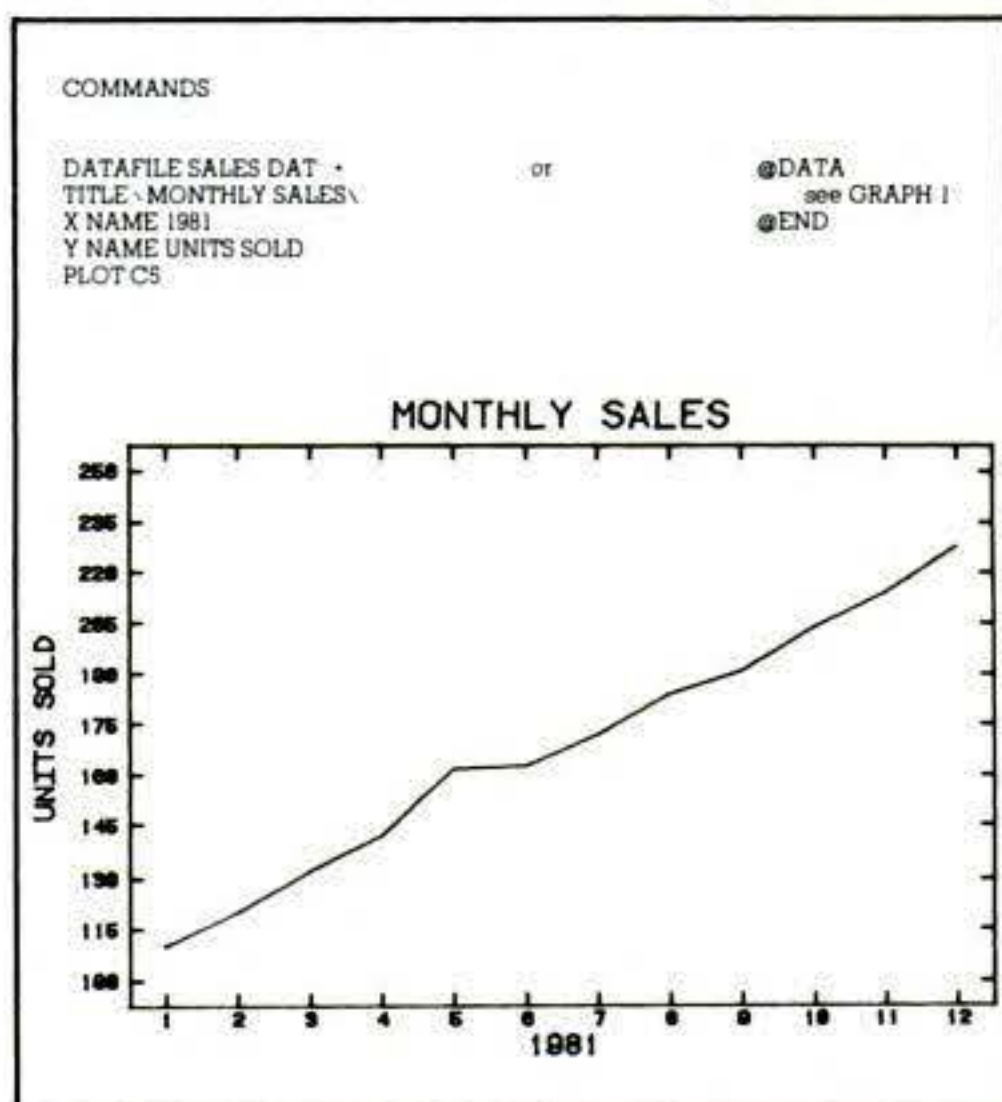
Naturally, to use Graftalk, your system must include a device for reproducing the graphics display: a graphics CRT, printer, or plotter. An **INSTALL** program, which is supplied with the disc, tailors Graftalk to work with any specific gear you choose.

Graftalk will not help you create vivid video games on your business-oriented computer. But it will make child's play of displaying complicated results in a meaningful way. Price: \$450.

Nibbles

Just about any school can teach a human to work with a computer. But only at Pennsylvania State University can a computer be taught to work with another computer. That's where Dr. Robert Owens has perfected a system that enables dissimilar computers to work together. Preliminary tests successfully teamed DEC computers with an IBM network system.

That's technically very difficult to do. But at the University of Vermont, Associate Professor Garrison Nelson has attempted the impossible with a program called Calliope; it's designed to make politicians work together. The program sorts



through its data base of timely political information and predicts how congressional votes will go on an issue. If the results are not to the politician's choosing, the program will tell whose vote is needed to swing things the other way. ("For the people, by the people"?) And speaking of politicians . . .

● Artificial intelligence will become the major growth area for computers in the 1980's, according to a study done by Brattle Research Corporation. Reasons for this conclusion: an enormous drop in hardware costs making artificial-intelligence technology commercially viable, the rapid commercialization of computer products, the lack of programmers, and of course, the inherent capabilities of a smart computer.

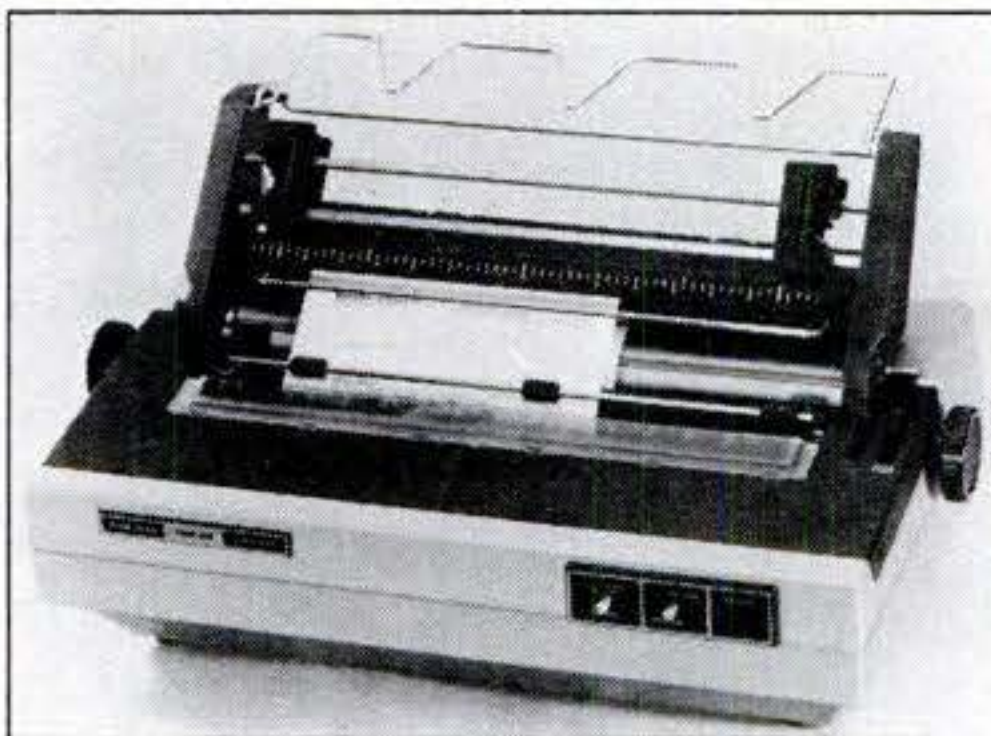
Meanwhile, scientists at Columbia University are preparing to build a "super computer"—far more powerful, they say, than the fastest existing machines. Instead of one central processor, it will use many, intermingled with memory. That will allow simultaneous operations. And according to Dr. Elliot Shaw, head of the project, such a machine "might spend a few minutes to do something that would now require a year's work."

● Two new computer networks: The American Medical Assn. is now on-line over the GTE Telenet Medical Information Network. Physicians can get instant, up-to-the-minute info on drugs and diseases

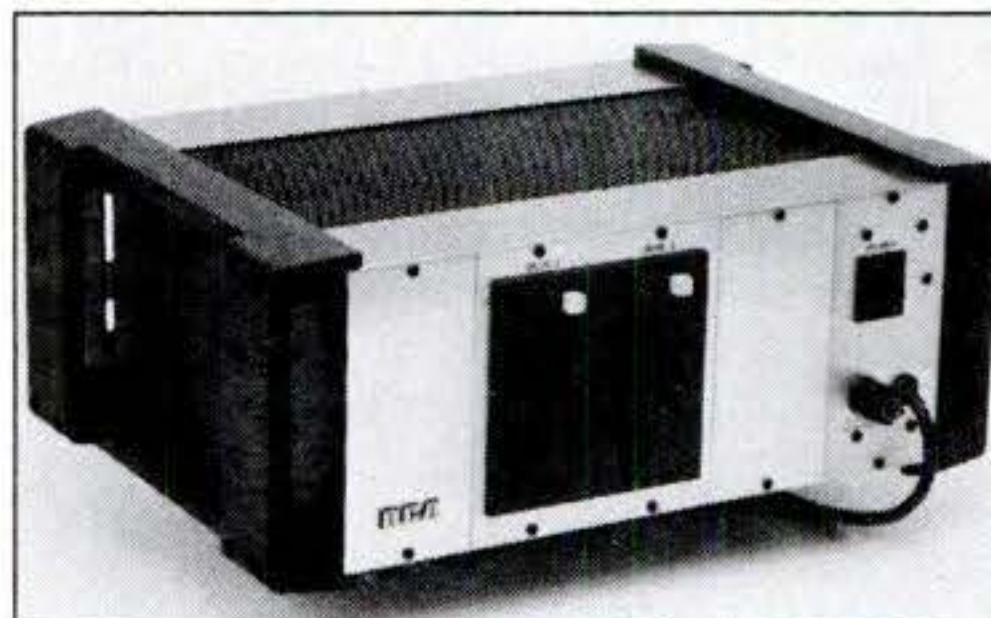
New add-ons

After a two-year study of 500 people who work with computer terminals, researchers at the New Jersey Institute of Technology found that 20 percent of the subjects became "addicted" to their CRT's.

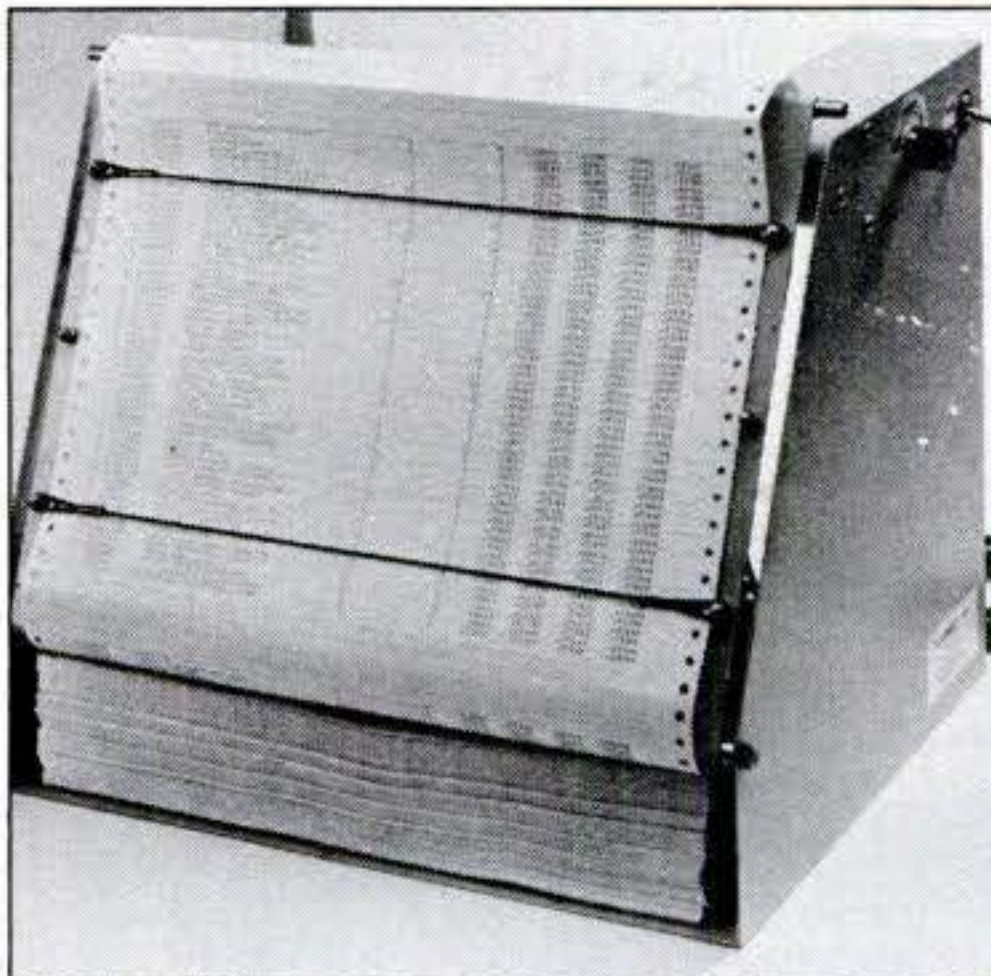
If you're like me and afflicted with the same problem, take heart. Manufacturers are supplying us with a steady stream of new gear to help support our habit. Like these:



Letter-quality printers that run at high speed usually mean big bucks. Exception: This Radio Shack Daisy Wheel DWP-140 model types about 30 characters per second but costs just \$1,495. A 15-inch platen accepts wide paper.

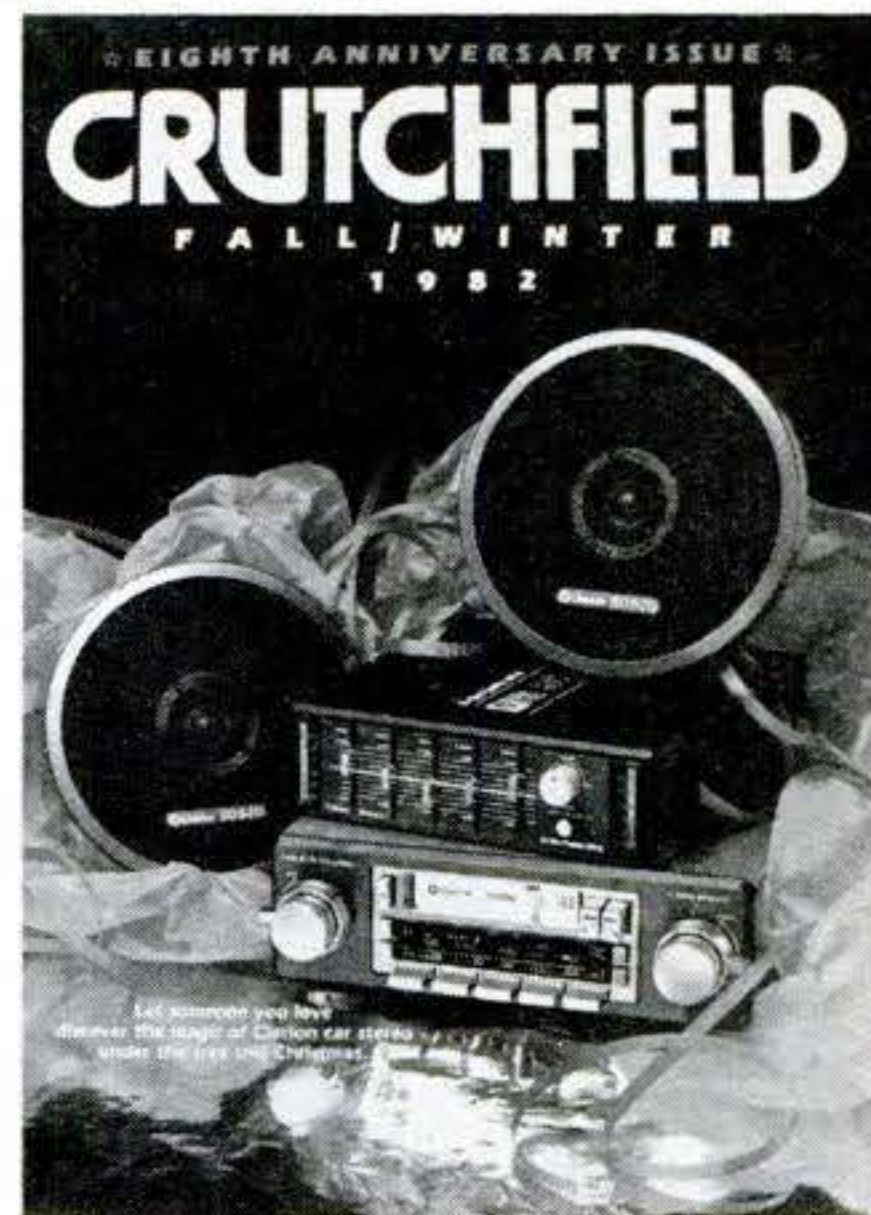


It all fits on a 12-inch chassis, but this RCA micro-disc development computer system has a 32K memory, power supply, and two 3.5-in. micro-floppy drives that hold up to 645K each. BASIC and Assembly languages are available. The entire system is priced at \$3,995.



Printing on fan-fold paper is easy—the computer does it. Reading it is difficult—left to fumbling humans. But Transmatic (Box 186, Roxbury, Conn. 06783) is motorized, moving up to a form a second past your eyes. \$368.

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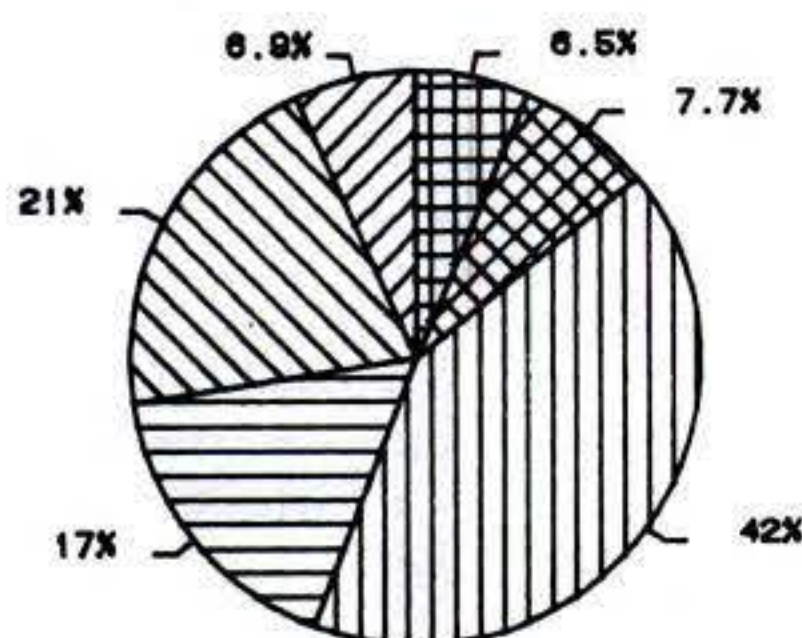
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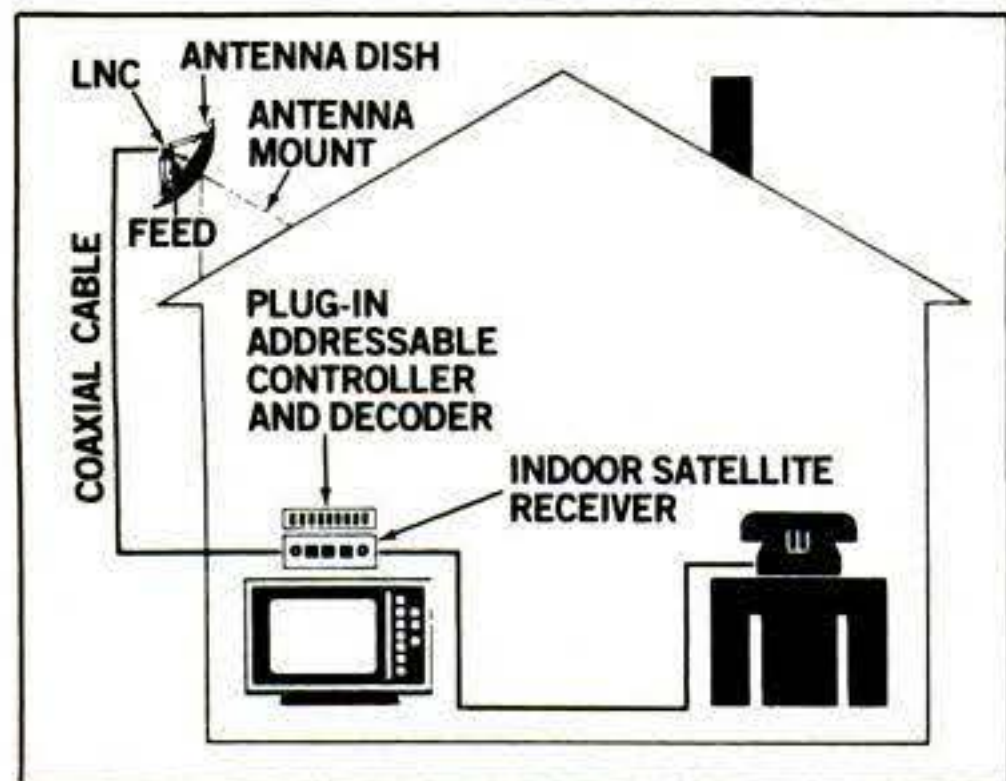
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or use its electronic mail system (\$100 per year, \$25 per hour of use). Agristar, from Radio Shack, is for farmers and ranchers. This system gives you data on agricultural marketing, production technology, news, weather, and electronic mail. Sign-up cost is \$200.

● Finally, a company called Farmtronix (555 Absaraka, Sheridan, Wyo.) is "steaking" its reputation that ranchers will think the new Cow Calendar program is "udderly" fantastic. It tracks the history of up to 250 critters on a range of subjects. I don't have a price, but you can bet they'll milk it for what it's worth.

LOOK AND LISTEN

By JOHN FREE



TV from a dish

Dish-shaped TV antennas such as General Instrument's four-foot parabolic above will appear on the roofs of homes sooner than expected. This compact design is slated for direct-broadcast-satellite (DBS) service—microwave TV beamed from space directly to homes—sometime next year. Jumbo dish antennas, nine feet and up in diameter, are also appearing in more back yards [PS, Nov. '81] and on apartment complexes for satellite master-antenna television (SMATV). And pint-size dish antennas for pay-TV multipoint-

distribution-system (MDS) signals, which are beamed from ground transmitters, may multiply soon, too.

G.I.'s dish entry is a joint effort with United Satellite Television to start a pay-TV satellite-to-home service in 1983—three years before some eight other firms begin DBS service. Initially, the United-G.I. service will cover the northeastern U.S. But by 1987, through expansion, United-G.I. hopes to reach about 95 percent of the homes not wired for cable-TV service.

Scrambled satellite signals from the dish antenna's low-noise converter (drawing) will be fed to an indoor receiver. A plug-in addressable decoder, through a phone link to central computers, permits pay-per-view programming. With the right code fed into your decoder, for example, you could watch a major sporting event.

Dish antennas for later (mid-1980's) DBS systems will be only 2.5 feet in diameter and will work with future high-power (200 watt) satellites. By contrast, the United-G.I. system will use medium-power (50 watt) satellite transmitters. Current Earth-station dishes must be nine feet or more in diameter to collect weak signals from the five-watt satellite transmitters now in orbit.

Still another microwave alternative to cable TV may be tested soon. CBS and Contemporary Communications Corp. have requested FCC authorization to test MDS frequencies (2.5 to 2.7 GHz) for fixed-site pay TV in several cities. Common-carrier MDS is often used for single-channel pay TV, such as HBO. CCC says it's devised a new adjacent-channel transmission technique that could beam four to eight TV channels into a small rooftop antenna. The MDS frequencies could also carry high-definition TV [PS, Nov. '81], and many non-video services, says CCC.

Multipath killer

Push buttons on Carver Corp.'s hi-fi gear often have unusual labels. During the past decade some remarkably effective circuits such as "sonic holography" ["High-

tech Hi-fi," PS, March '81] and Carver's so-called "auto correlator" noise-reduction system have appeared.

Now the firm's latest FM tuner, the digital-readout TX-11 (photo), has two switches, under the joint label ASYMMETRICAL DETECTOR, called NOISE REDUCTION and MULTIPATH REDUCTION. Reflections from buildings and other obstructions can produce multiple FM signals (multipath) that distort audio. And when stereo-FM signals are weak, the background hiss can make music unlistenable.

Switching noisy stereo FM to the monophonic mode will cut background hiss. But Carver has devised circuits that maintain the stereo illusion, reduce noise, and minimize multipath distortion, as well. For patent reasons, the firm isn't disclosing details. But apparently playing a role in the circuits is a charge-coupled device (CCD). These semiconductor chips can serve as a solid-state substitute for TV camera tubes [PS, Jan. '82], or they can electronically delay signals. According to Carver Corp., the TX-11 can convert previously unlistenable stations into acceptable hi-fi.

Quick looks

- Digital-audio-disc (DAD) players [PS, Nov. '81] are rolling off assembly lines for the Japanese market. In Japan, Sharp introduced its 13-by-six-by-nine-inch DX-3 machine for \$635. DAD's are 4.7 inches in diameter and are "played" by a beam from a semiconductor laser. Music is encoded in a digital format on plastic-protected disc surfaces. The DX-3, which can be programmed to automatically play 20 selections, should join a flood of DAD players expected to be introduced in the U.S. next year.

- Pulse-code-modulation (PCM) tape machines use digital-encoding technology similar to that of DAD's for super-fidelity hi-fi. Sharp has also unveiled a prototype PCM tape recorder in Japan that can capture 60 minutes of music on a regular C-60 audio cassette. High-density PCM signals are recorded and played back with 16 thin-film heads. Sharp has also introduced a PCM adapter for video-cassette recorders that is expected to sell for less than \$800. Such adapters, which now cost considerably more, put PCM signals in a format suitable for VCR decks.

- Hi-fi approaching the quality of PCM hardware should be available for stereo-sound TV in Sony and other Beta-format VCR's in 1983. New stereo Beta decks, shown in prototype form last summer [PS, Nov. '82], will combine an FM-stereo signal with the video track. The new stereo recording method achieves extraordinary fidelity compared with the ordinary VCR audio track. New stereo Beta tapes will retain this monophonic (or stereo) track for compatibility, making cassettes that have three separate language tracks feasible.

- General Electric's prototype Comband hardware compresses two cable-TV channels into the spectrum space used by one. Comband will enable cable-TV operators to double capacity without rewiring

Continued



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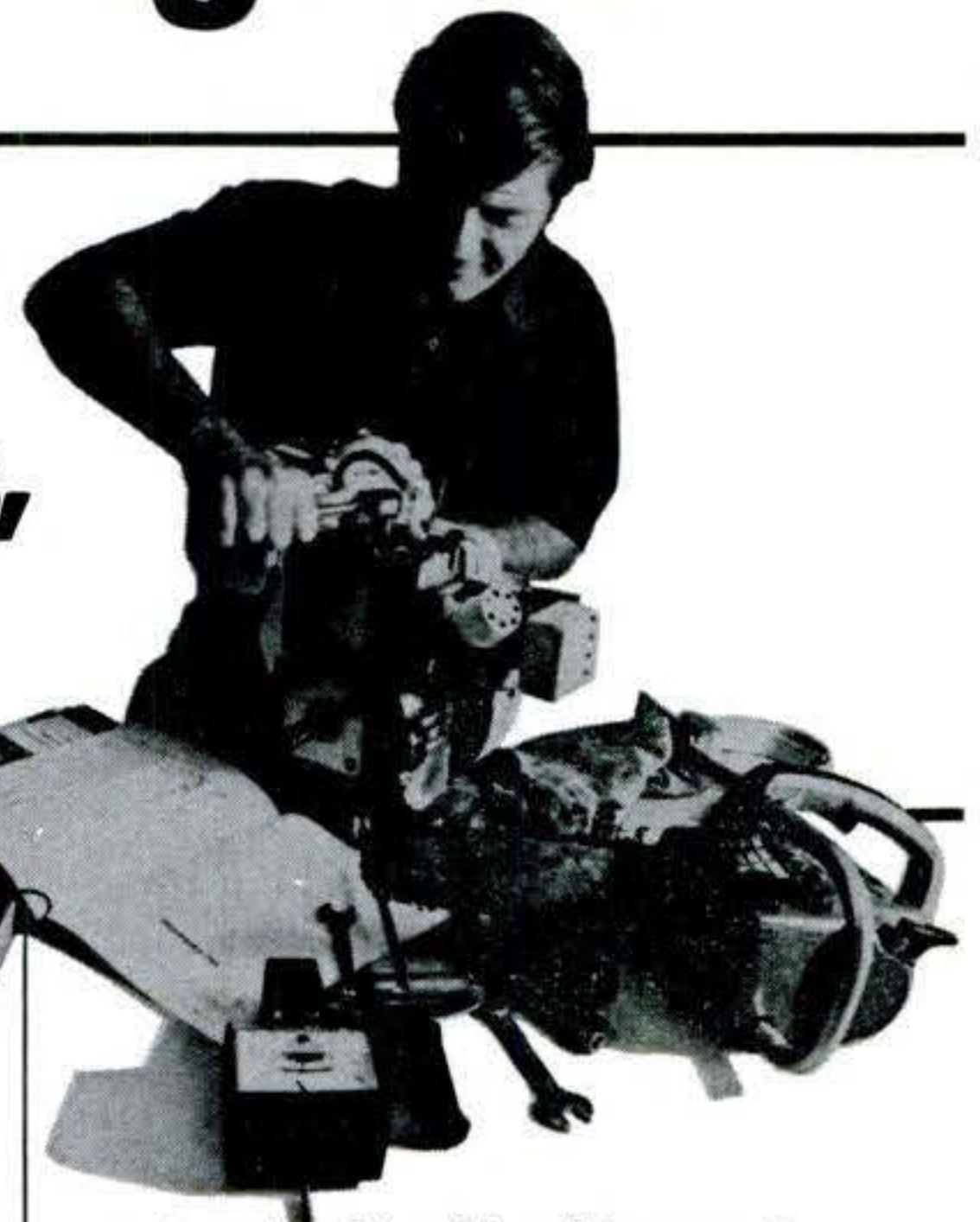
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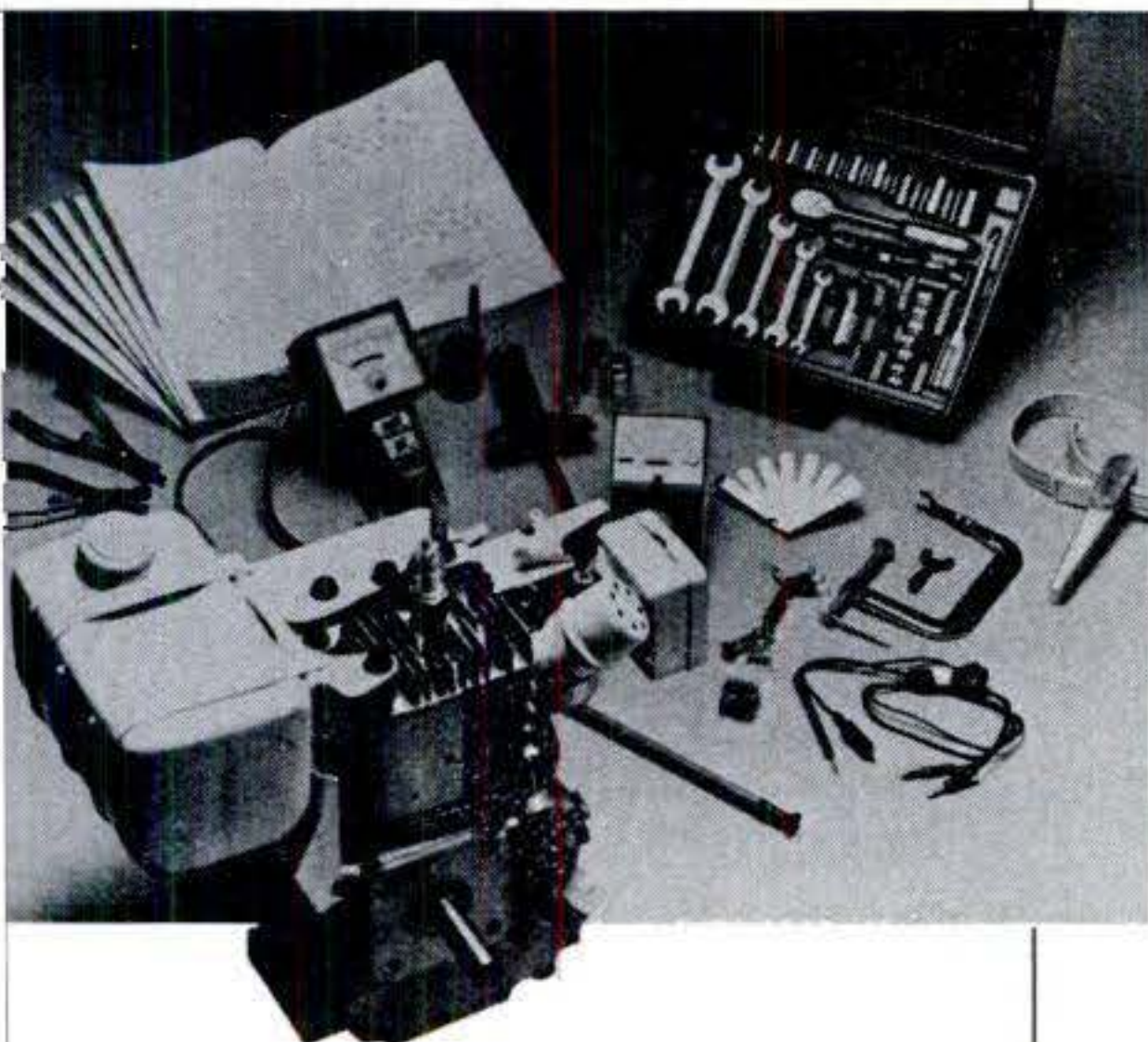
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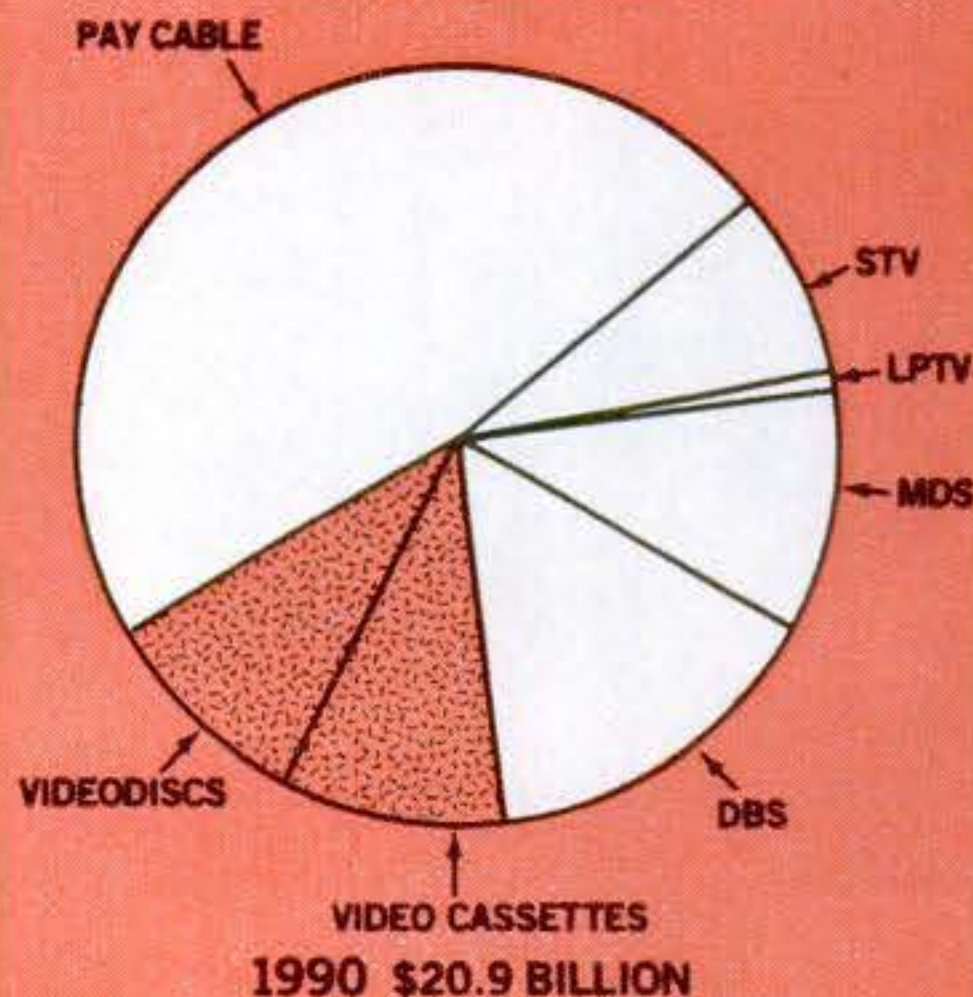
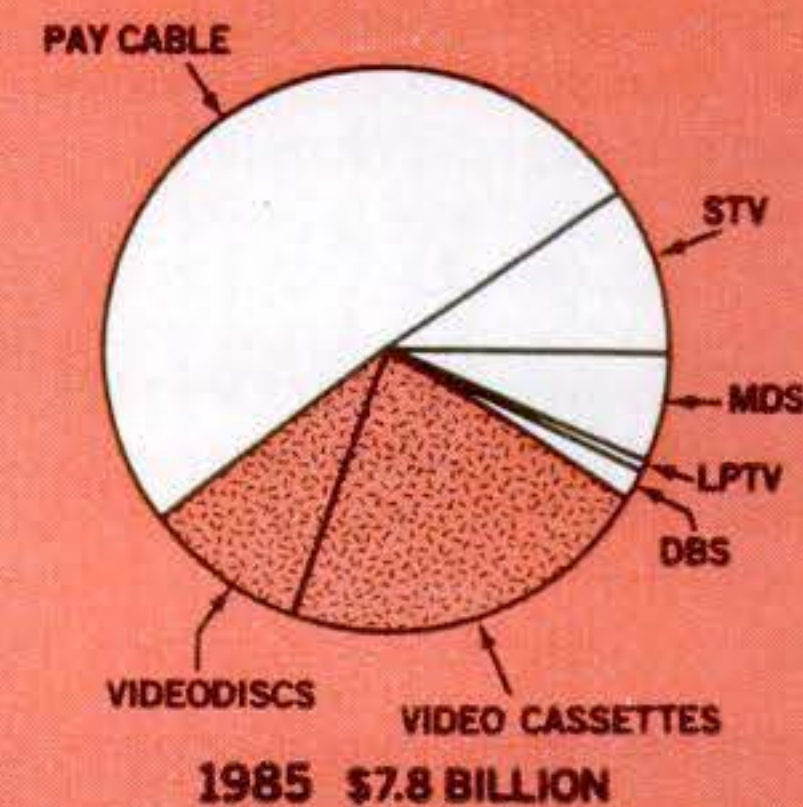
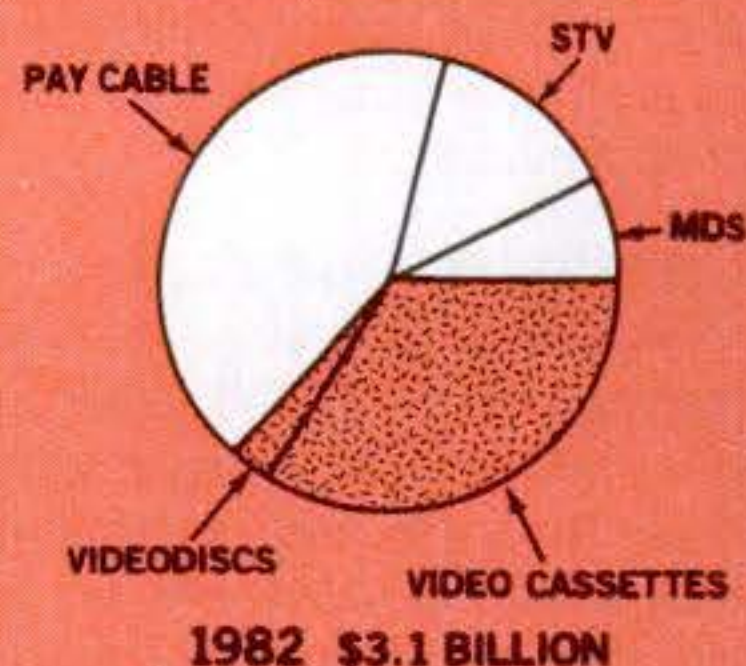
[Continued]

systems—a step that's usually necessary.

● Will you be watching pay TV or video cassettes and discs in coming years? International Resource Development Inc., a Norwalk, Conn., market-research firm, concludes that most of us will be using various forms of pay TV. IRD's recent report predicts that pay TV will increase its share of viewer revenues from 63 percent in 1982 to 82 percent of the pay-TV-home-video-software market in 1990 (chart).

IRD suggests that subscription TV (STV) should exploit its present lead, while MDS and low-power TV (LPTV) operators should "cherry-pick" programs desired by viewers from satellites. The report argues that consumers prefer the convenience and freshness of pay TV, with its variety of programming, over renting or buying tapes and discs.

Projected shares of pay-TV/ video-software revenues



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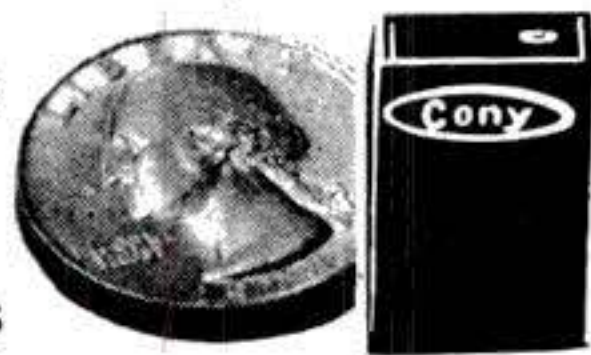
Model X-18 is the longest-range microphone, with an unbelievable two-mile range. Introductory price is \$149.95 (two for only \$139.95 each).

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SUPER-EAR is undetectable from the other side of the wall. The quality of sound has amazing fidelity—good enough to record, and SUPER-EAR has its own built-in recorder jack.

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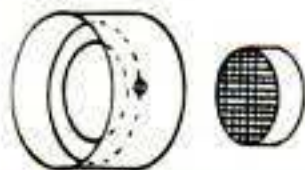


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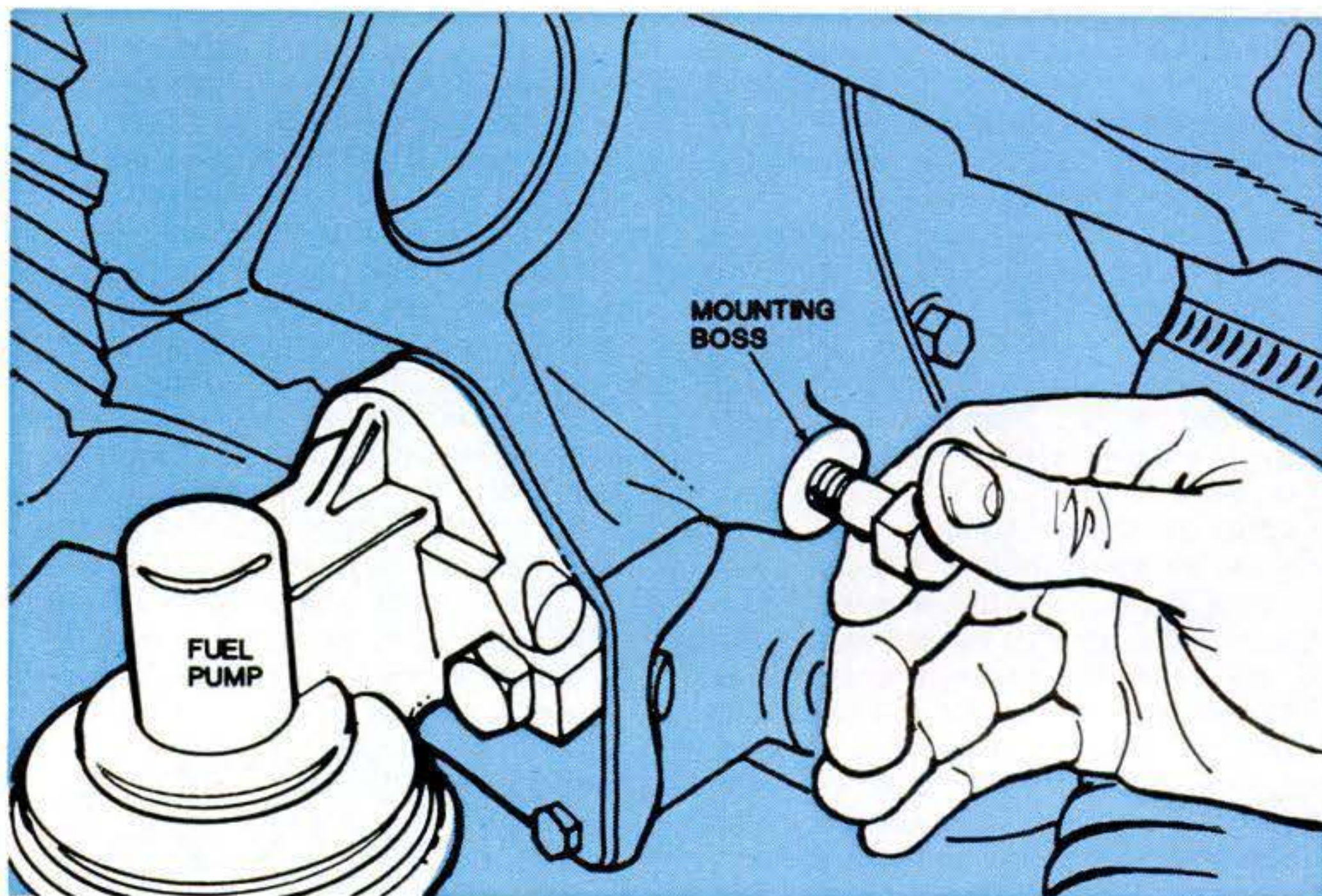
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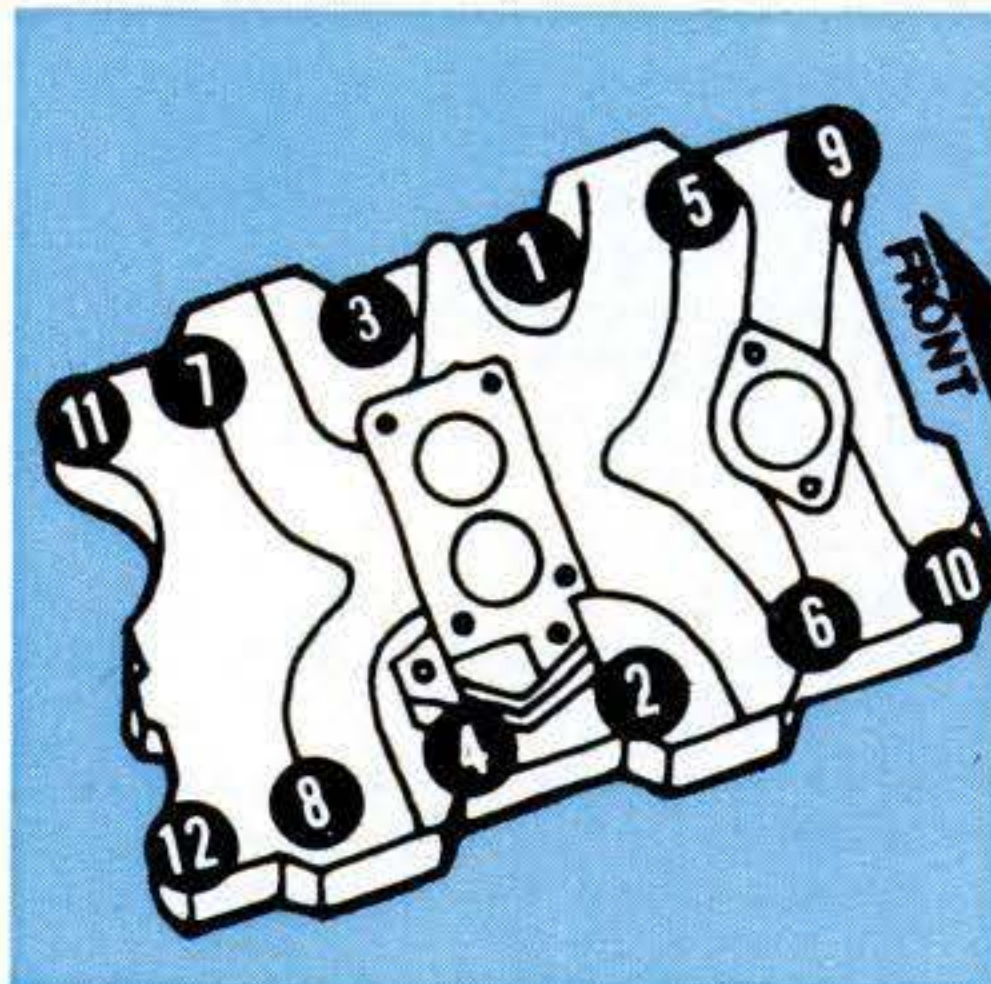
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Chevy fuel-pump trick

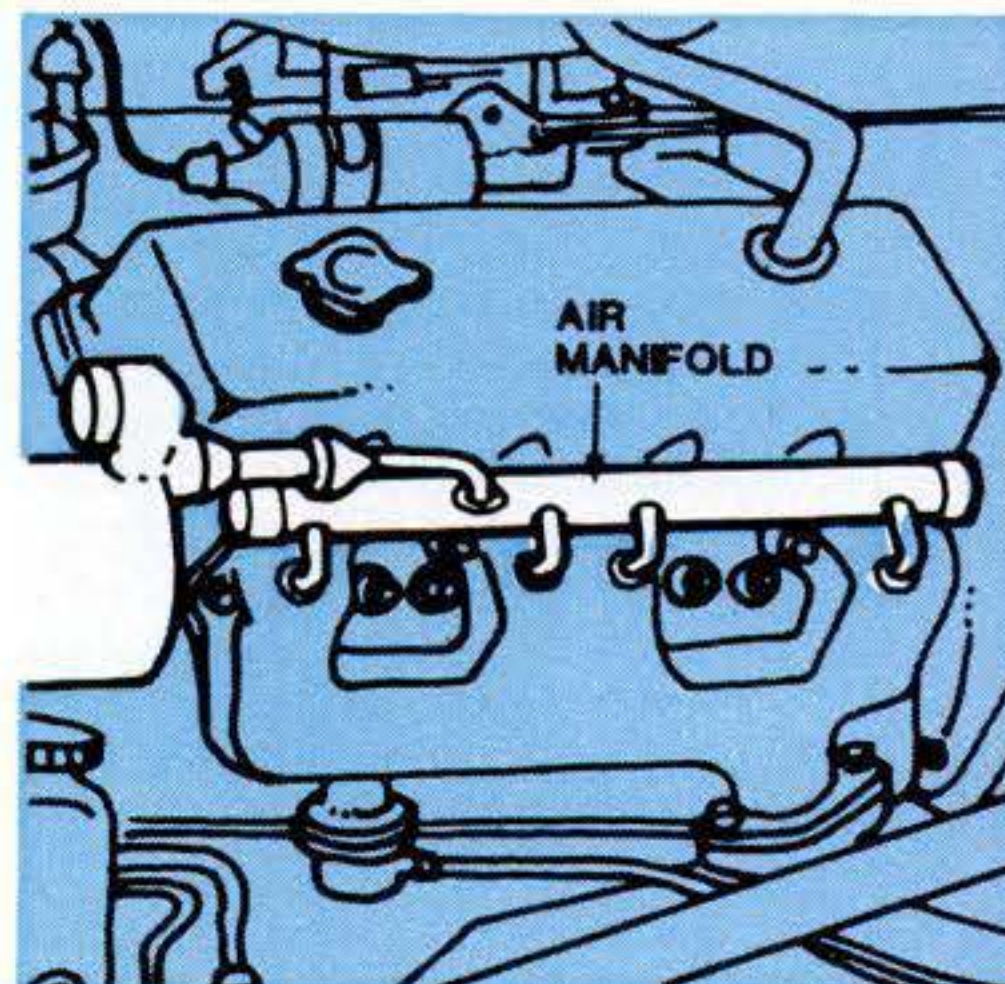
Many V8's use a push-rod-driven fuel pump. When replacing the pump on small-block Chevy engines, aligning the push rod can be frustrating and difficult. Here's a handy trick to save skinned knuckles. Before you take out the pump, remove the upper bolt from the engine's right front mounting boss. This bolt's hole

is in alignment with the pump push rod. Put a longer bolt (3/8-16 by 2 in.) into the hole. Finger-tighten the bolt until it bottoms against the push rod. (Do not over-tighten or you'll damage the push rod.) You can now remove the fuel pump, and the push rod will stay in place. Remember to reinstall the original bolt after service.



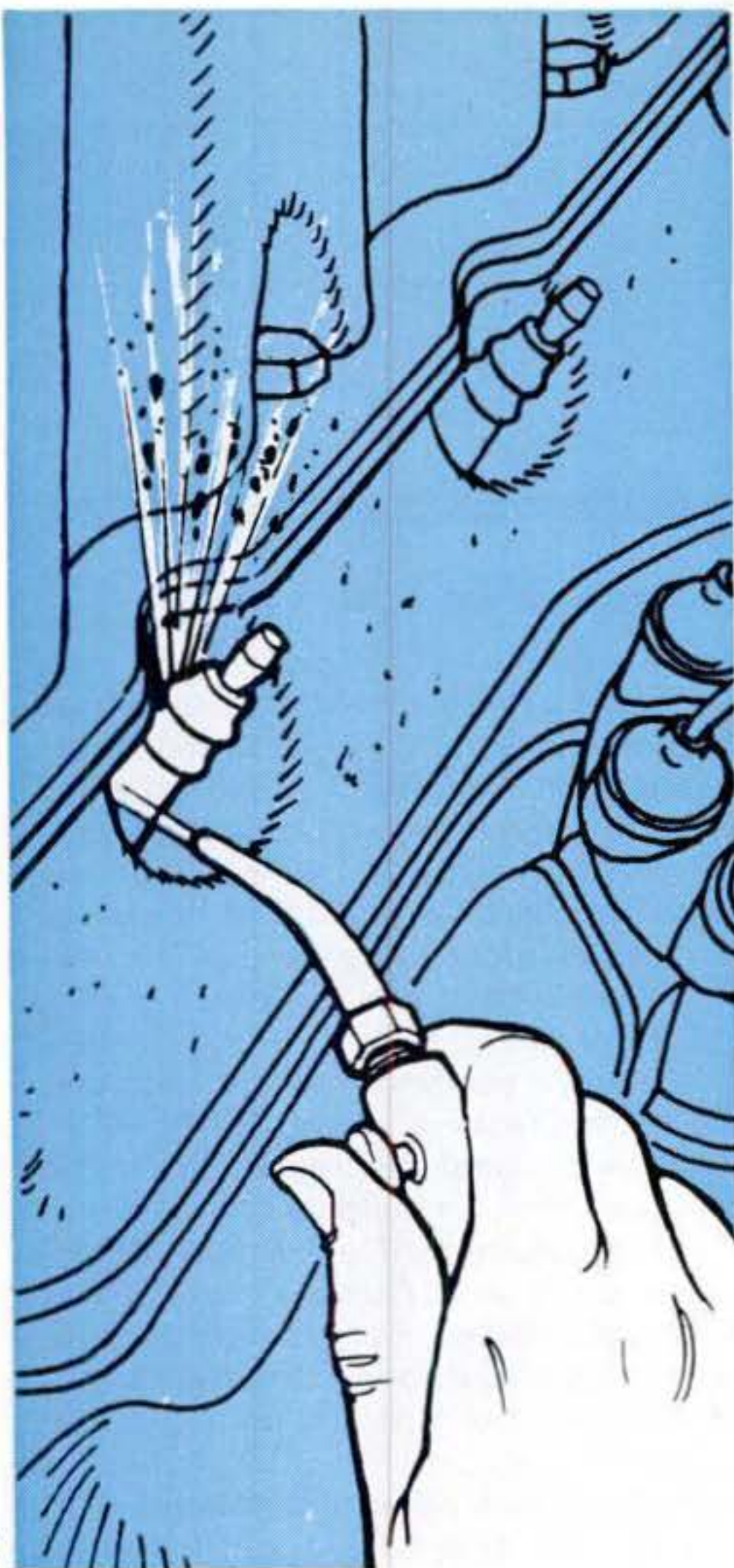
Lean air-fuel mixture

An important step that's often overlooked when doing a routine tuneup is to re-torque the intake manifold. A loose manifold often creates a lean air-fuel ratio and causes a rough idle. Tightening the manifold will usually correct minor air leaks and eliminate the problem. Follow the manufacturer's recommended tightening sequence (sample above) and torque specifications in your car's manual.



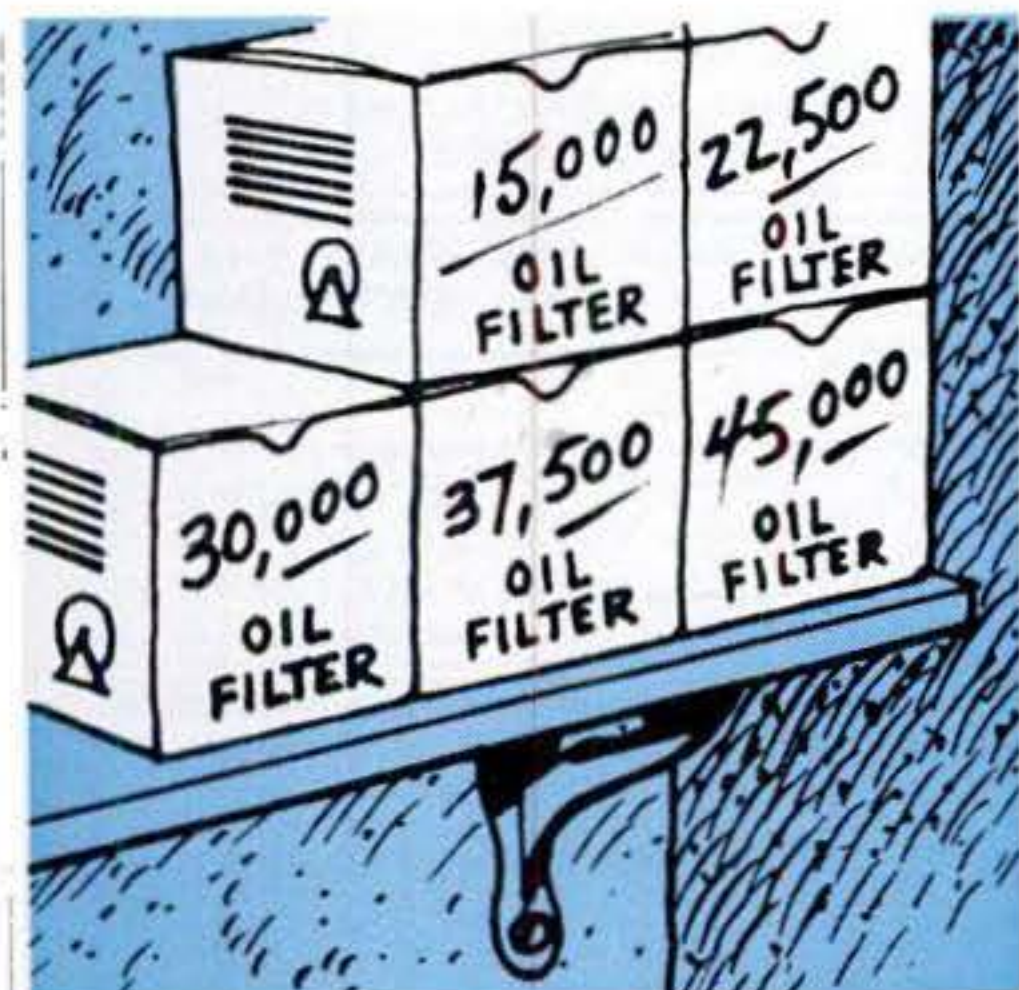
Exhaust noise

An annoying exhaust leak can sometimes be traced to a faulty emission-control-system component. If your car's engine is equipped with an air-injector-reactor (AIR) system, the noise could be coming from a hole in the air manifold. To locate a leak, snap-accelerate several times to about 1/4 throttle. Each time you blip the throttle, look for signs of escaping exhaust smoke from the manifold.



Spark-plug safety

Failure to blow dirt away from the area around a spark plug before its removal can cause problems. If debris falls into the spark-plug hole, damage to the cylinder wall, piston rings, or valves is possible. To prevent this, loosen all the plugs one turn, and give the area around each a blast of compressed air. (Wear goggles.)



Oil-change record

Changing oil and filters at the regularly scheduled maintenance intervals is important for keeping your car running well. But do you get tired of trying to find records or read grease- and oil-smudged labels in the engine compartment? Why not purchase oil and filters when they're on sale? Write the oil-change intervals directly on each carton. With a quick glance, you'll know if one is due.

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The above is from "The Book of Bugs", a free-wheeling personal statement and sales catalog written by our Head Bug. His book is outspoken, insulting, irritating, pugnacious, ascerbic, and annoyingly honest. Best of all, it's **FREE**.

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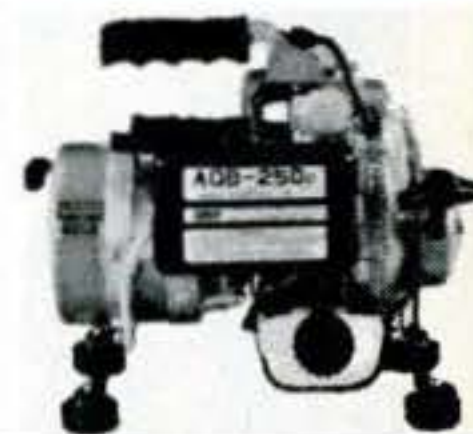
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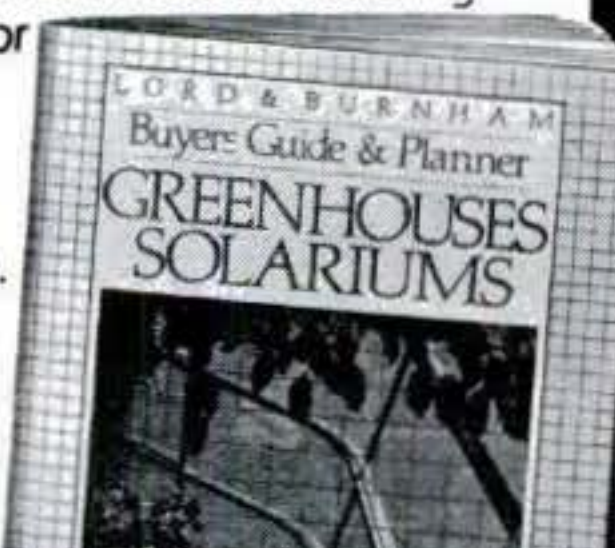
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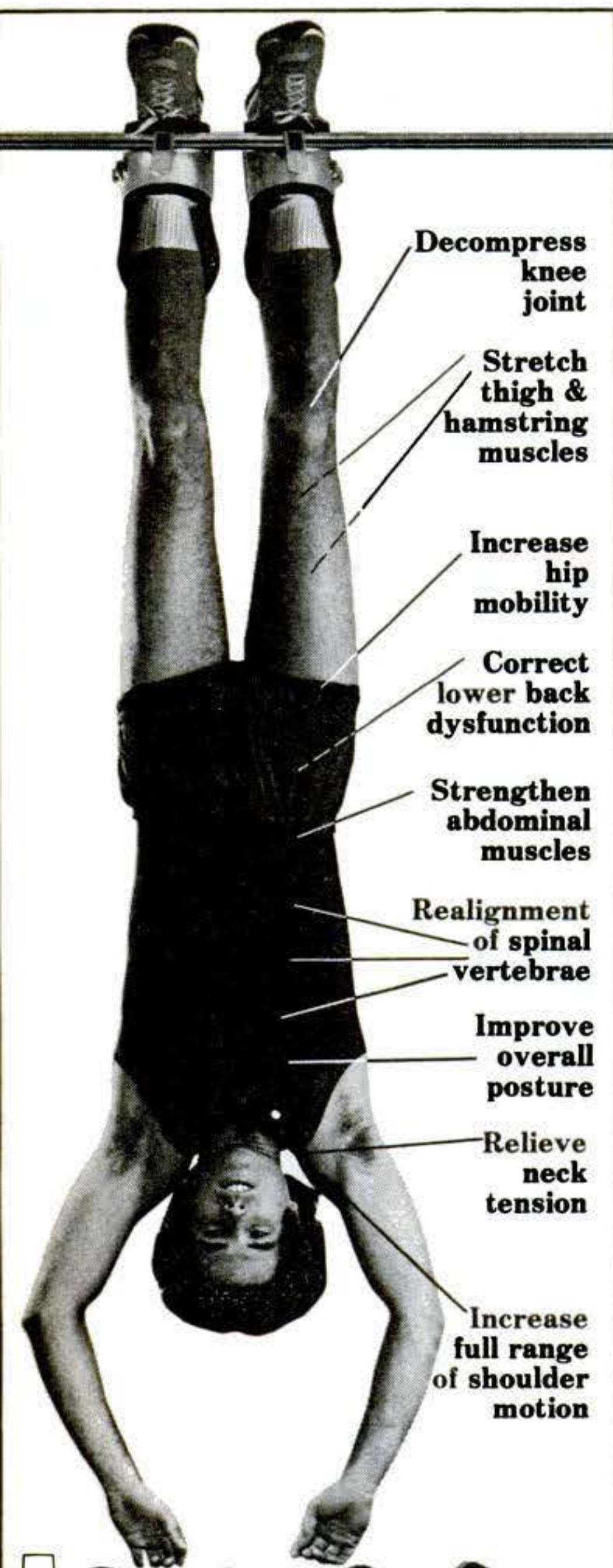
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SHOP TALK

By AL LEES

Updated energy adventure

Three guest writers kick off this month's column. Rich Day, our consulting editor for home and shop, had reported (in "Adventures in Alternate Energy" in the September 1978 issue) on the solar water-heating system built by his neighbor on Palomar Mountain in California. Day files this update:

"Steve Beardsley now teaches in Camas Valley, Ore., where he's built a new version of his system with improvements that enable the one four-by-eight-foot collector shown in his photo to do the same job as the pair he left behind here on Palomar. Though he's now in a poorer solar locale, he gets better performance from less area, at much less cost. His expenditure for the entire system—including a used 52-gal. storage tank—was \$388.

"The cross-section sketch shows that the new design has better insulation, tighter construction, and more-effective tubing arrangement. To minimize heat loss, the collector fins are mounted close to the glass cover and supported on insulated angle brackets. As before, Steve has silver-soldered the copper tubing and flat copper fins, but he has improved the manifold and riser piping."

If you want those details, mail a stamped, self-addressed envelope to Rich Day, Palomar Mountain, Calif. 92060. The other changes in Beardsley's original design are shown in this sketch.

Build your own hydro plant

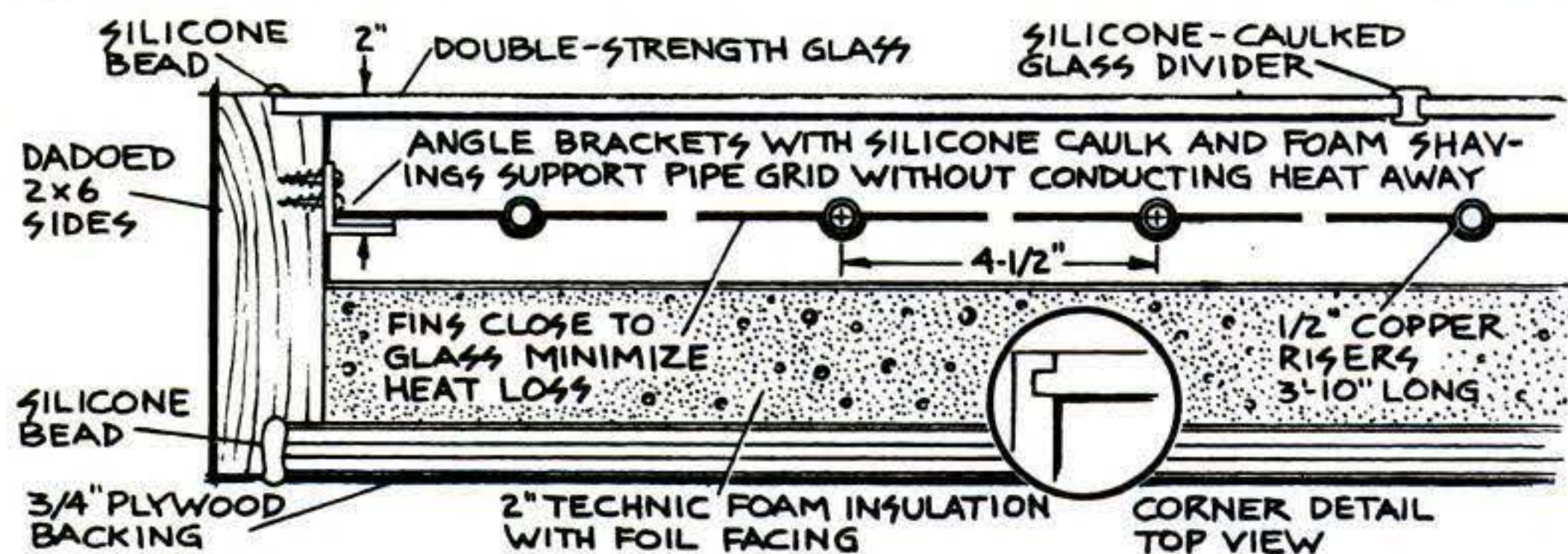
Every few weeks I'm deluged with a new shipment of paperback books from Tab, a publisher that seems to grind them out like sausages. Since I can't keep up with the flow but don't relish missing the occasional title of real merit, I welcome guest reviews from staff members of books in their special areas of expertise. Here's such a review from our engineering editor, E. F. Lindsley:

"It's always seemed that the best we could do for readers asking for how-to-build data on small hydroelectric plants was to refer them to builders and vendors of hydro equipment. Now a new book, *How to Build and Operate Your Own Small Hydroelectric Plant*, by J. George Butler, takes you through one man's experiences with the nuts and bolts of such a project.

"Since all hydro plants are site-specific, he necessarily gets deeply into his own problems, but these are so typical that you can easily relate them to your own site. Even better, his readily understood discussions of the whys, wherefores, and technical aspects of hydro plants, equipment, and hookups is good reading for anyone contemplating a hydro plant.

"Especially important, his use of a conventional centrifugal water pump running in reverse, rather than a much more expensive turbine made only for water power."

Continued



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Shop talk

[Continued]

er, is a real breakthrough and news of the first water. Actually, some very thorough engineering on this novel idea has been done by the Worthington Group of McGraw-Edison Co., and prospective hydro builders will do well to investigate the use of these off-the-shelf pumps.

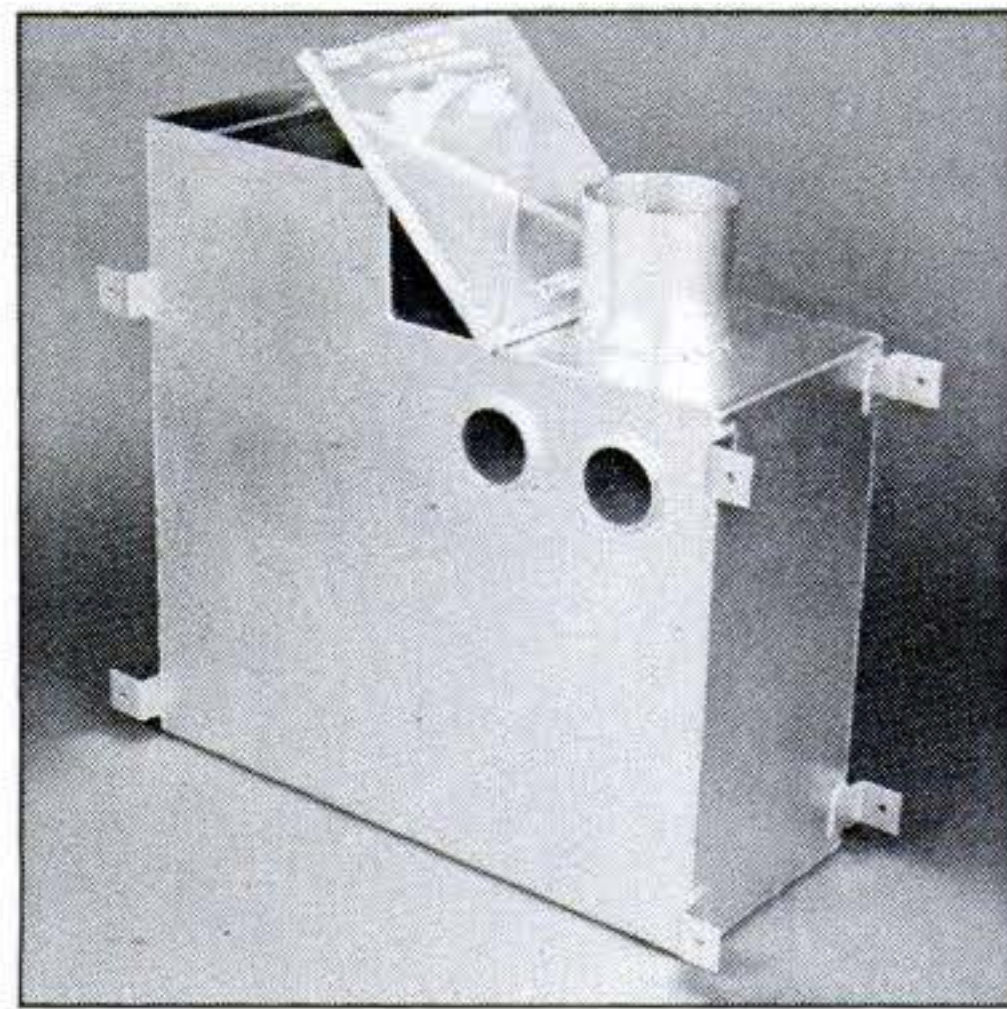
"The 304-page paperback costs \$11.95 and is published by Tab Books, Blue Ridge Summit, Pa. 17214."

Trapped in the vault

Louis Hochman, whose swinging bookcase/storage vault appeared in last November's issue, writes: "I discovered a new use for my secret closet. Since the bookcase laps the door frame and acts as an efficient light baffle, the closet's a perfect darkroom for unloading film. But first make sure the doorknob works from the inside. Too late, I found myself trapped when the knob, missing its setscrew, spun freely. My muffled cries brought help before things turned morbid."

Fire in the water

Why are these soaking snowbirds smiling? Because behind that slat partition is a submerged wood stove, blazing away. I kid you not: The new Snorkel Stove (bottom photo) burns wood or coal so efficiently that the Seattle maker claims an



output of 120,000 Btu/h. It's aluminum, so no rust—and fast heat transfer. Since this system needs no electricity, pumps, or plumbing, it's ideal for remote sites. It sells for \$425. Roger Evans, Box 20068, B'way Sta., Seattle, Wash. 98102.

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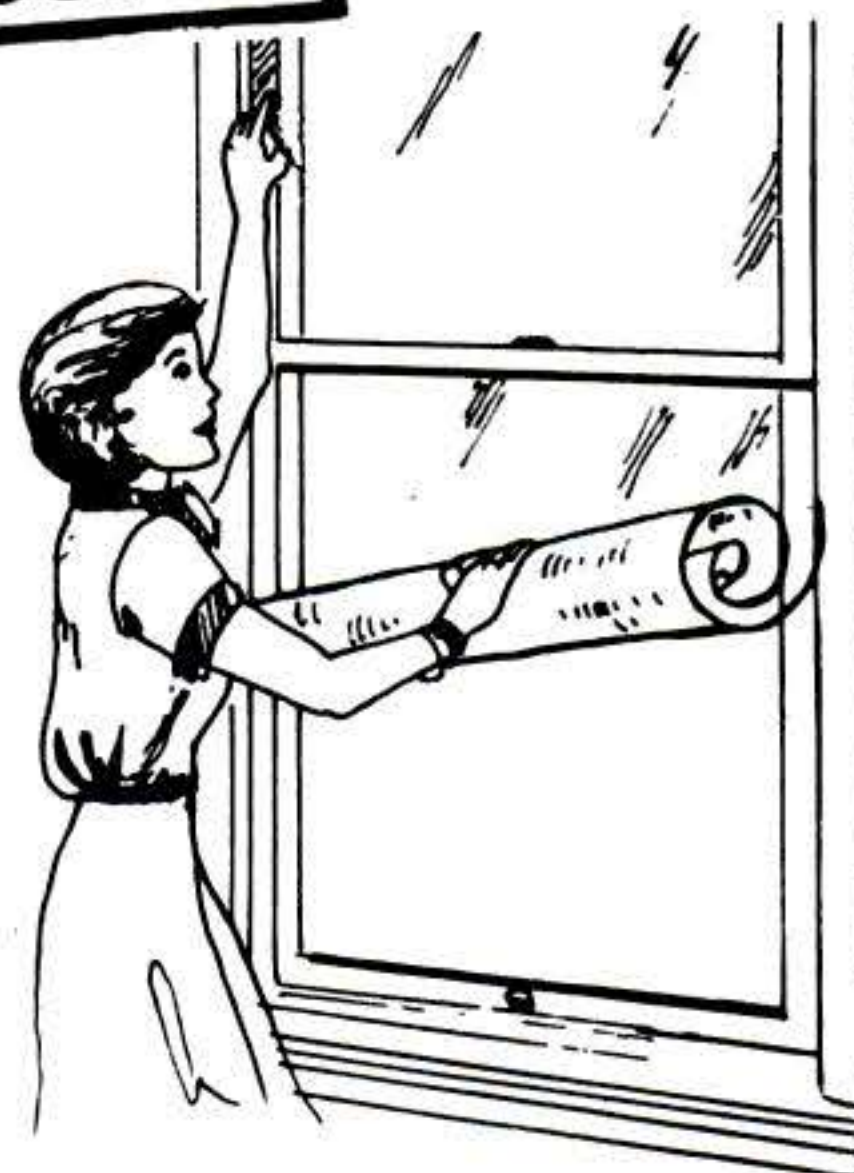
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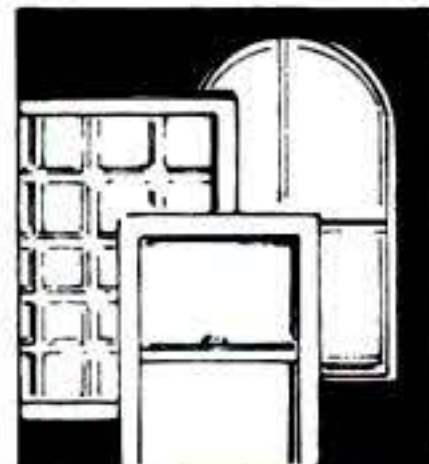
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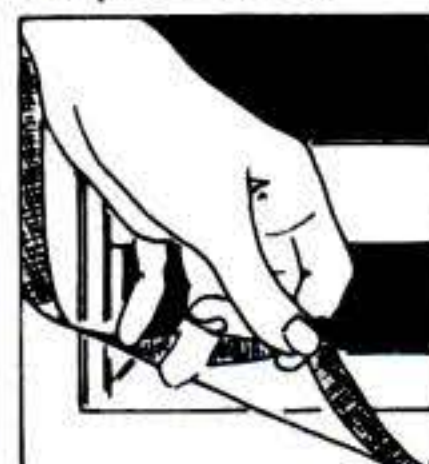
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ALTERNATE-ENERGY ANSWERS

By JAN F. KREIDER

Jan F. Kreider is a consulting engineer specializing in the design and economic analysis of solar-energy and energy-conservation systems. He is the author of several books on solar technology, and a lecturer at the University of Colorado.

Heat blockers

There appear to be two types of rigid insulation approved for use in homes. Please compare them.

Jake Horman, Alexandria, Minn.

Actually there are four rigid insulations, if you include Fiberglas board and foam glass. However, I assume you are referring to polyisocyanurate and polystyrene. An example of the former is Thermax and of the latter, Styrofoam. Both products are lightweight and have low water absorption and good chemical stability. However, there are a number of key differences, listed below:

Feature	Polyisocyanurate	Extruded polystyrene
R-value	7.5 per inch	5.0 per inch
Cost	2-3 times cost of polystyrene	1/2-1/3 cost of polyisocyanurate
Temperature limits	250 deg. F (or higher, with special precautions)	170 deg. F
Compressive strength	25 psi	14 psi

Polystyrene is available in either expanded (white) or extruded (blue) form. The blue form is easier to cut and install than the white form, which is also called "bead-board" and does not match the perfor-

mance characteristics of the extruded type. Polyisocyanurate and blue polystyrene cost about the same to install, but since polyisocyanurate costs more per unit of installed R-value it is used most where space is limited or high thermal resistance is needed.

Something for nothing?

How can I obtain information on heating my home with a solar pool? The solar-energy centers I've queried have been unable to help.

J. Ed. Hart, Jacksonville, Fla.

You can't directly heat an entire house with a pool. However, if used as a heat source for a heat pump, a pool can provide part of a home's heat requirement. A water-to-air heat pump will be needed. Of course, the pool's stored heat must come from somewhere—a solar pool heater, for example.

Half-baked Alaska?

I have a homemade solar hot-water heater and a "hot" problem. Just how hot can the sun heat water, given Alaskan conditions? Running pipes five feet underground for about 100 feet, I have gotten 120-deg.-F water.

David Schroer, Homer, Alaska

Don't confuse temperature with heat. Solar systems become less efficient at higher operating temperatures. Therefore, a given amount of solar collectors capture more heat at lower temperatures. Of course, there is a practical limit to how low a temperature is useful—about 110 deg. F for residential hot water. When I visited Homer last August, it was 80 degrees and sunny. Under those conditions you can efficiently produce water at 130 deg. F or so. With the short days and low temperatures typical of Alaskan winters, performance will obviously be reduced.

Controlled air supply

What are the advantages and disadvantages of installing an outside air supply to a gas-fired, forced-air furnace? Would it result in any significant energy saving by reducing the amount of cold-air infiltration into the house? Would it have any adverse effects on the furnace?

Brian E. Laux
Rochester, N.Y.

Outside combustion air is preferred. Infiltration and uncomfortable drafts are substantially reduced if a separate outside-air source is used. If you plan to retrofit an outside-air duct, do so with the minimum restriction possible to maintain good burner efficiency. Also, place a screen or grille over the outside opening. The opening should be located in a sheltered area so that north winter winds cannot extinguish the furnace pilot light.

Cellulose and moisture

I must decide soon if I should have fiberglass insulation blown into the walls of my two-family home at a price of \$1,500. The attic floor has been done before. I now have aluminum siding on the outside walls, and my fuel bill is approximately \$2,000 per year. Could you give me your unbiased opinion?

Thomas Catucci
Meriden, Conn.

The insulation most often blown into existing stud spaces is cellulose with an R-value of 3.3 per inch. In your climate, you may have a problem with moisture condensing and freezing within the insulation on cold, winter days. Unless a vapor barrier is installed—impossible with a blow-in job—the insulation will eventually deteriorate and settle. If you had not just installed aluminum siding (of little insulating value by itself), I would have recommended removing the old siding, installing a vapor barrier and new board insulation, and then re-siding.

Got a question on an alternate energy such as solar, wind, water, or wood? Wondering about energy-conservation techniques for home heating or cooling? Every other month, alternating with "Adventures in Alternate Energy," Jan Kreider answers selected questions from readers. Send yours to "Energy Questions," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Individual queries can't be answered by mail.

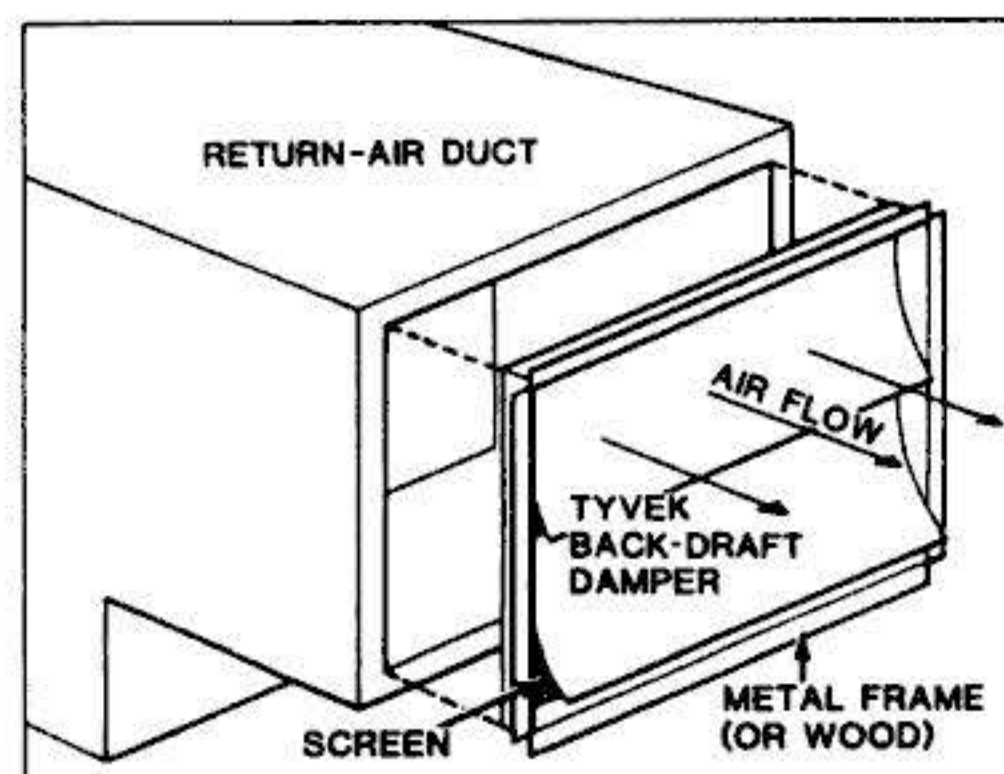
FOLLOW-UP

On dampers

In response to the item about back-draft dampers in the July column, Randy Granger of Helio Thermics, Inc. (Greenville, S.C.), correctly points out that standard metal dampers, because of their weight, could restrict air flow in return ducts of air-type solar systems. He suggests an alternative method using Tyvek flexible plastic manufactured by Du Pont (drawing). The damper can be installed at any convenient point in the collector return duct. In the collector-to-storage or collector-to-space mode it will automatically open to admit air to either the storage box or the space to be heated via the collector loop. In the storage-to-space mode, internal duct pressure (below building pressure) operates a second similar damper in the house return-air duct.

On ash traps

Regarding our item about use of an ash-trap air source for fireplace combustion



air [PS, May '82], William R. DaBoll writes, "Not only is it feasible, it's highly desirable." A product made specifically for this application, called the Fire Genie, replaces the existing centrally located ash-dump door unit in the fireplace floor and has an integral air damper for complete control of incoming air.

If you'd like more information, write to DaBoll at 10008 W. 98th St., Overland Park, Kan. 66212.

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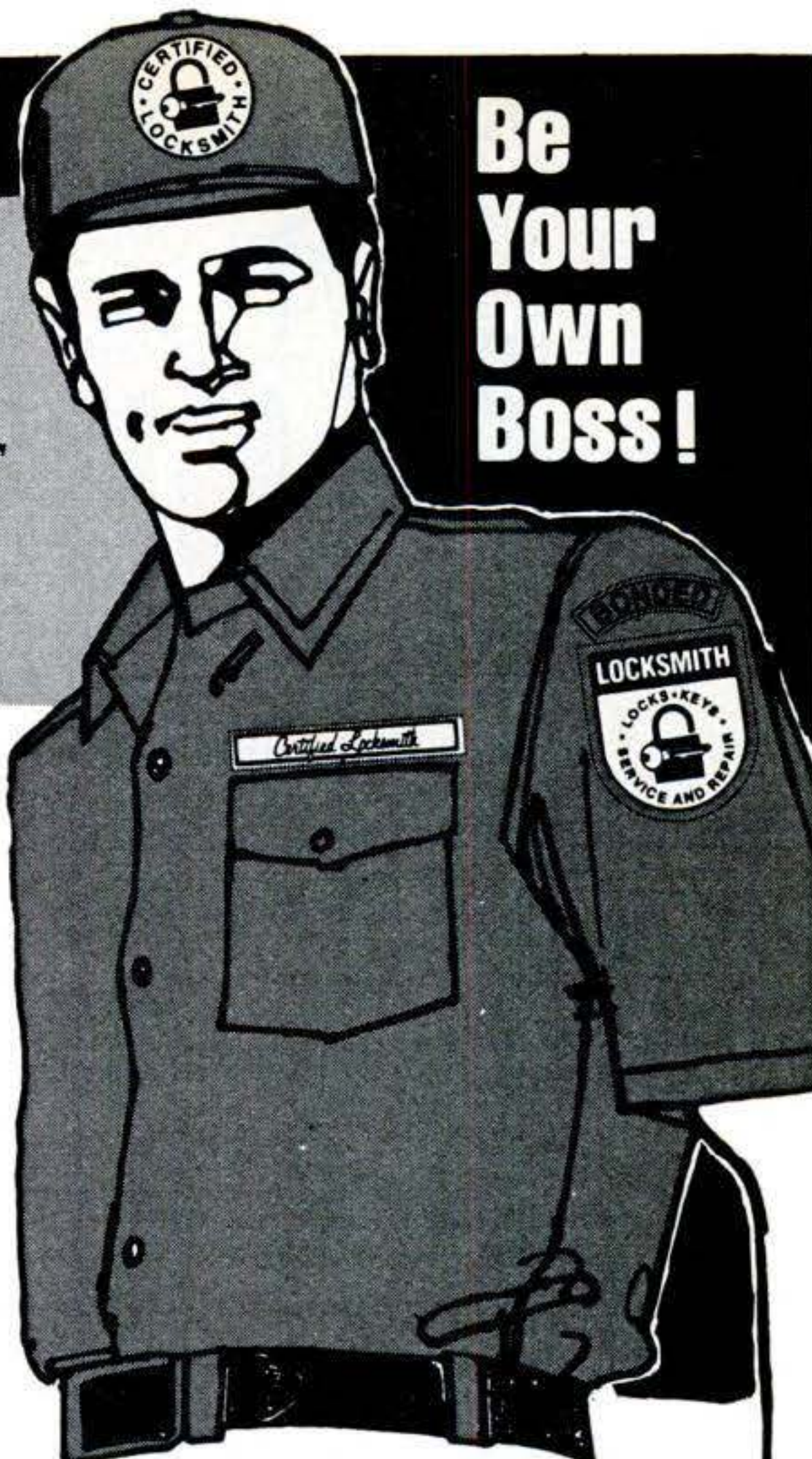
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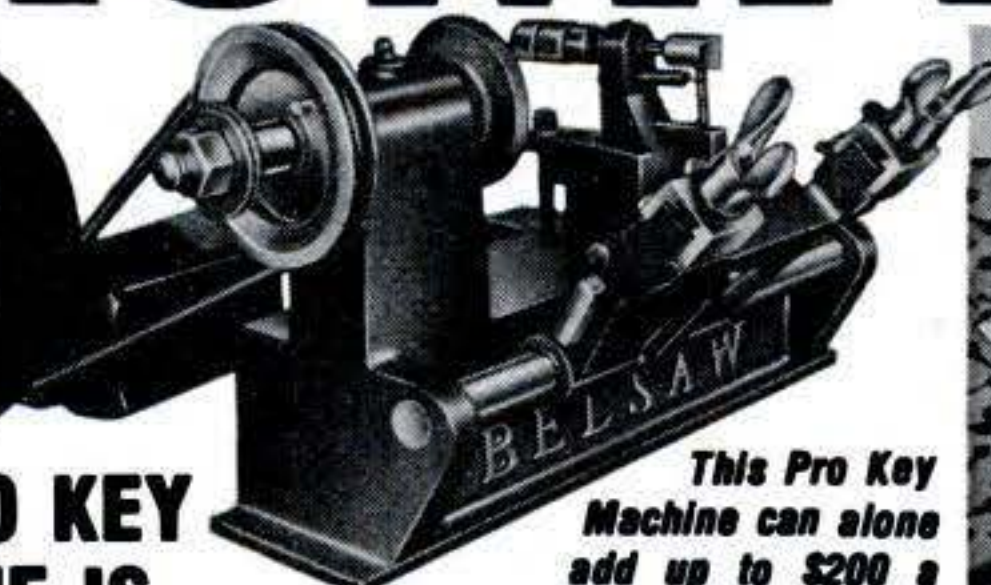
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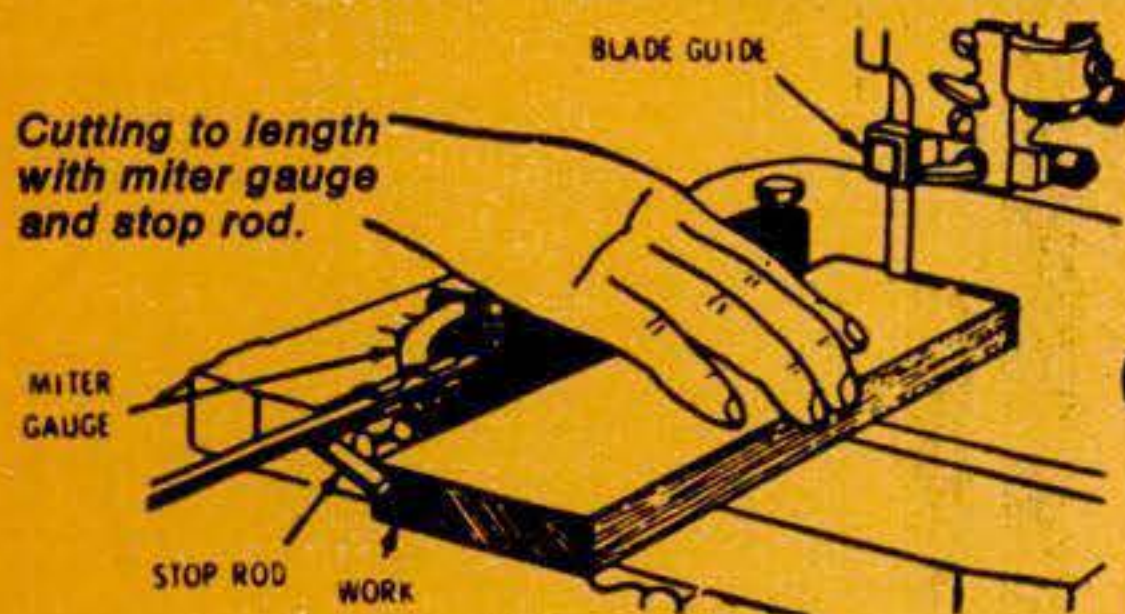
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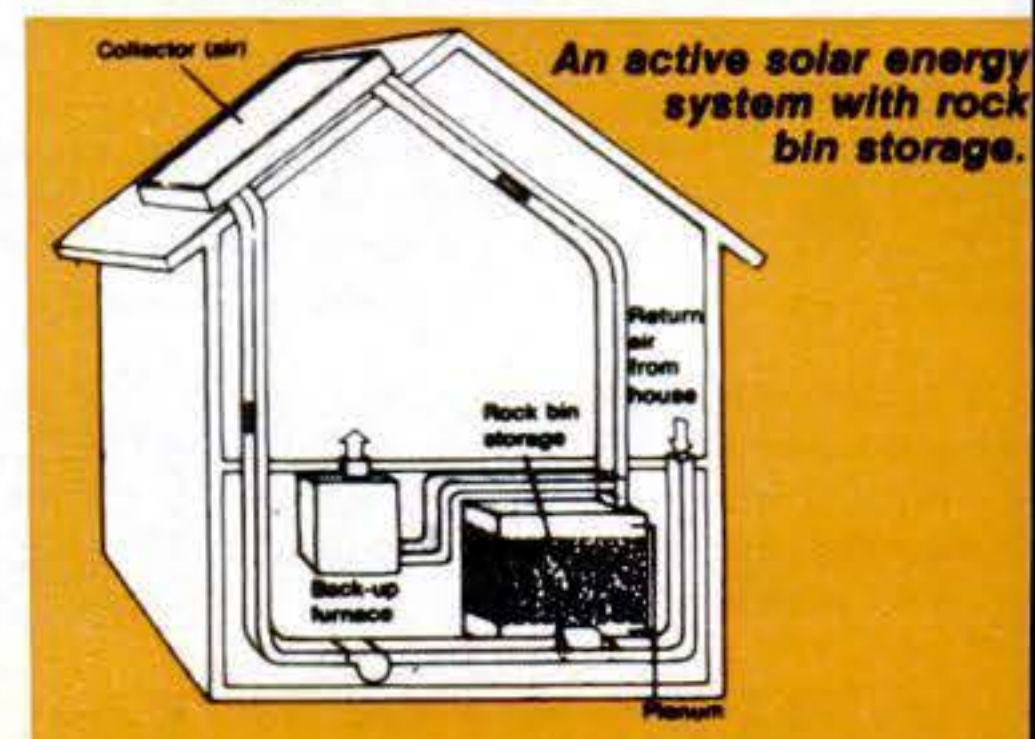
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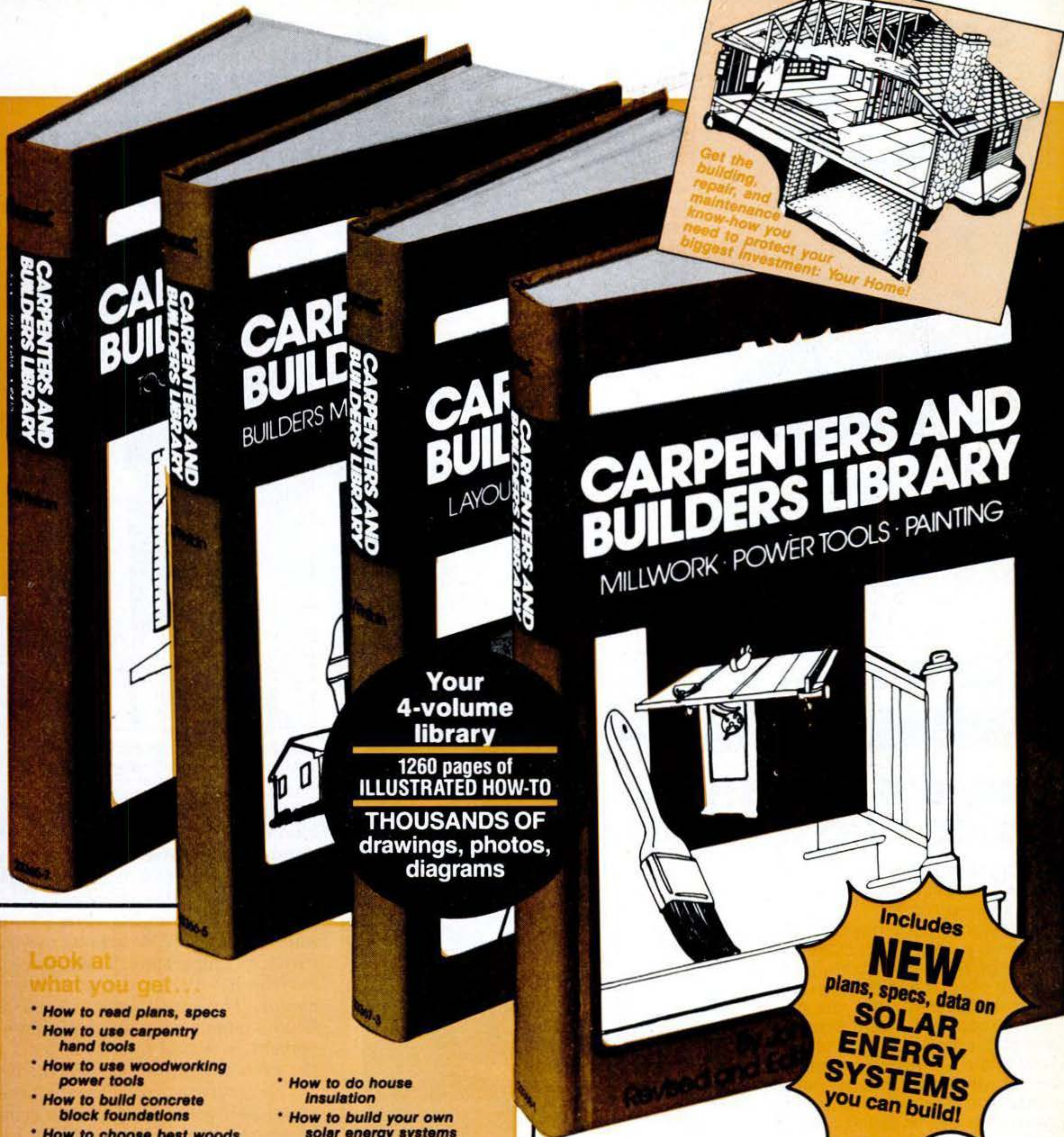


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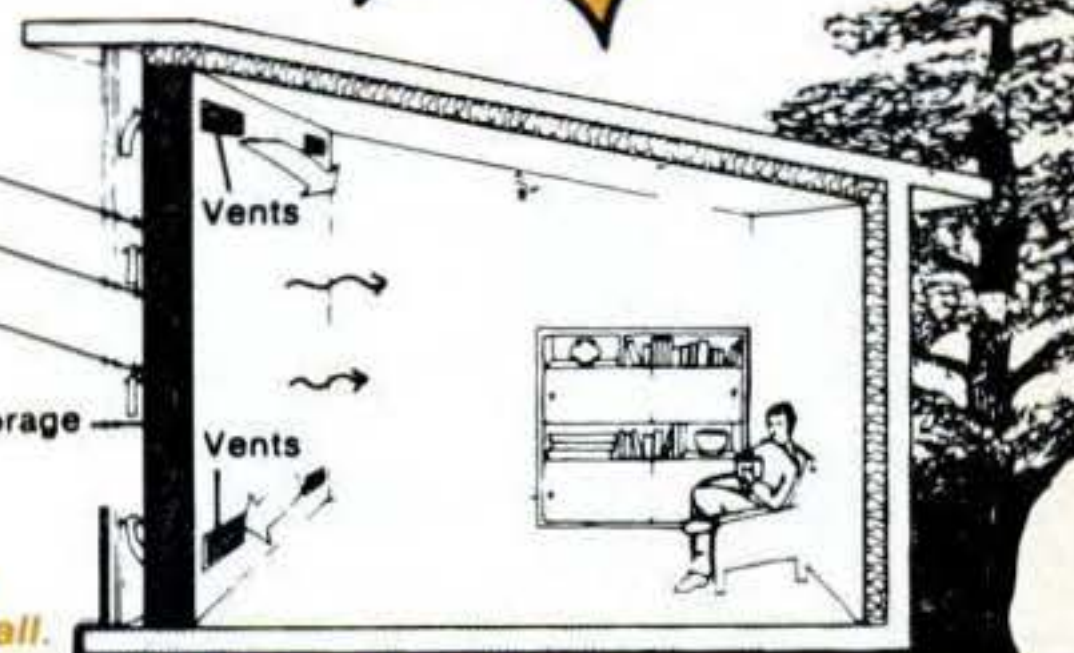


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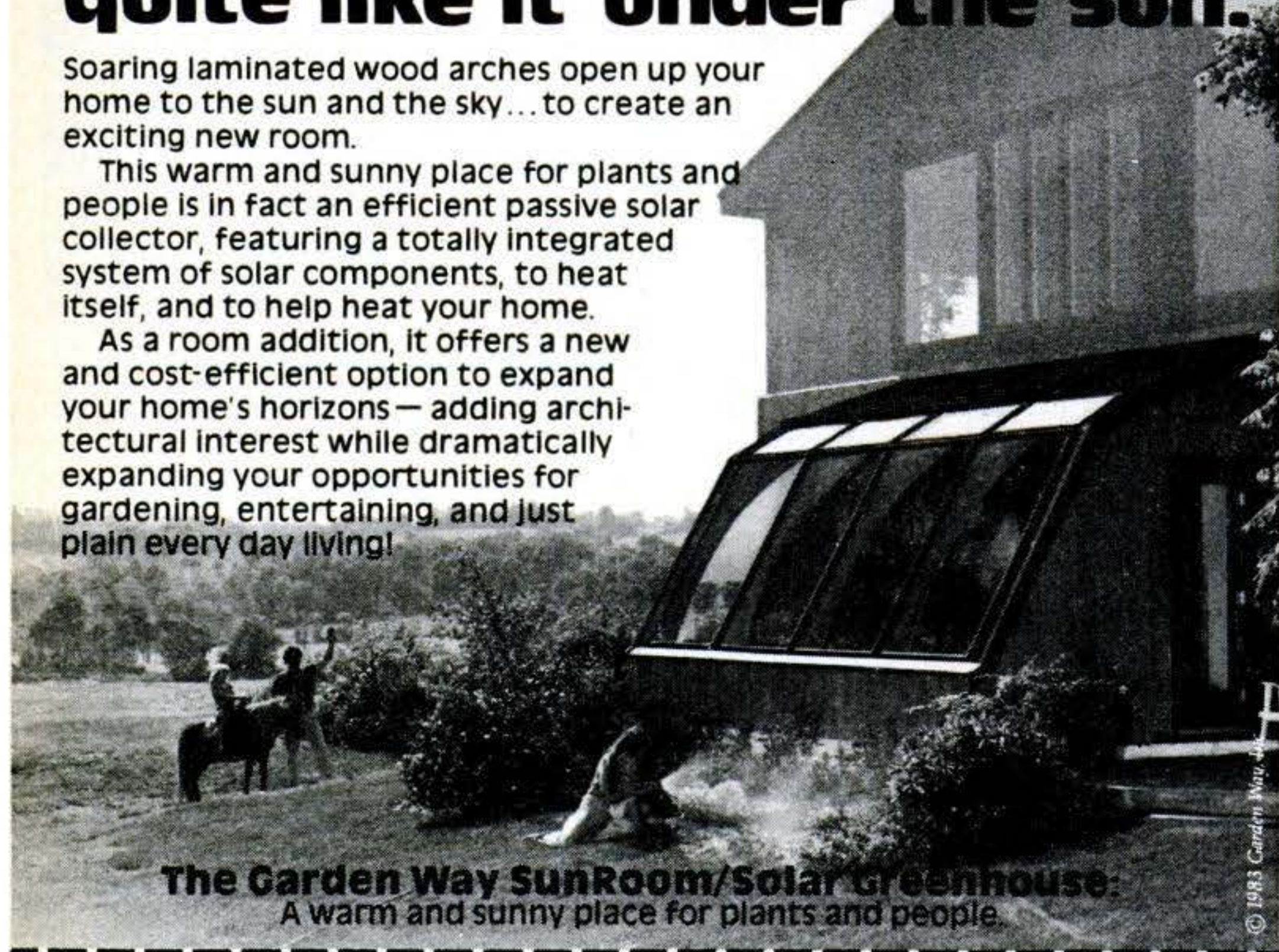
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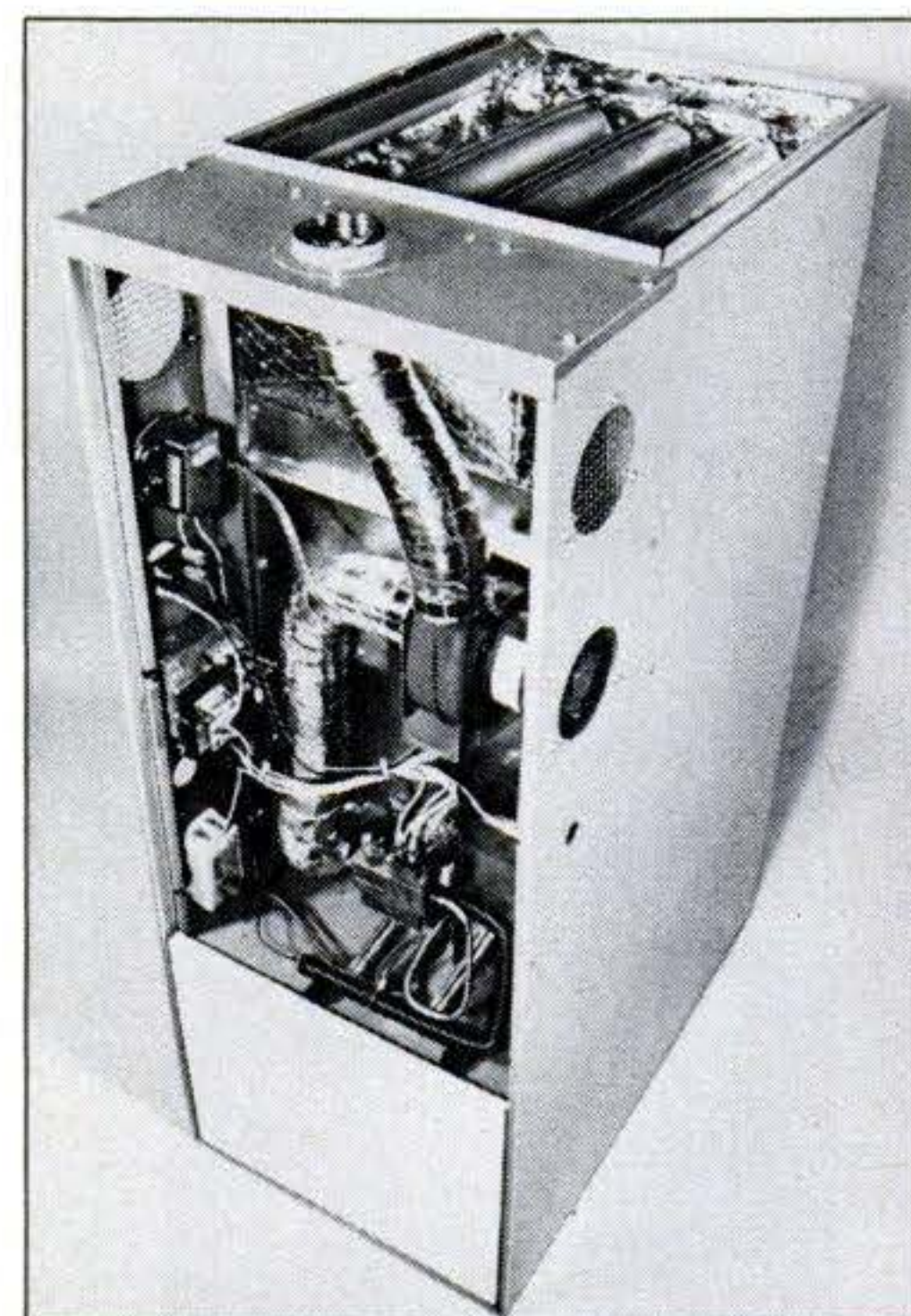
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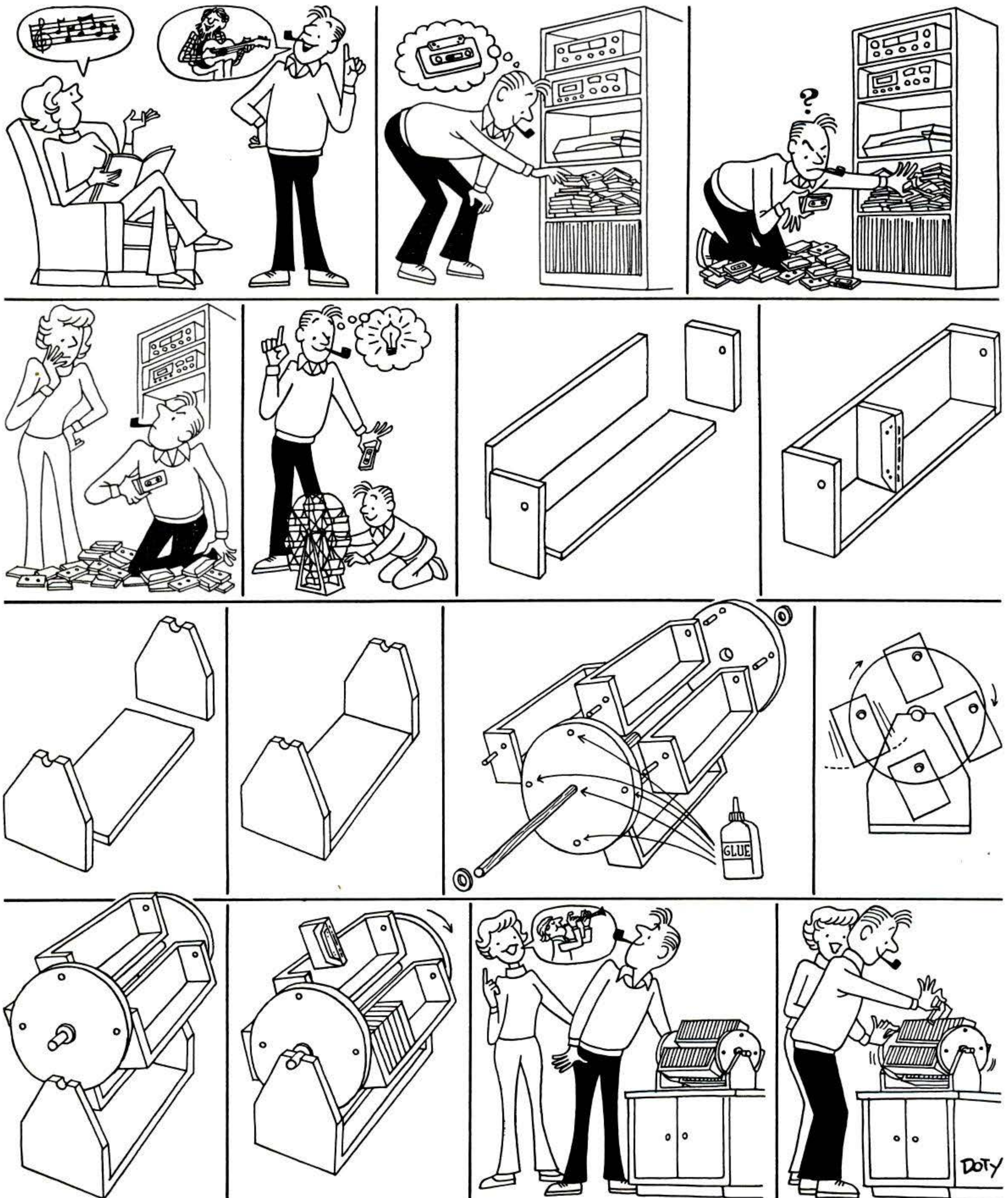
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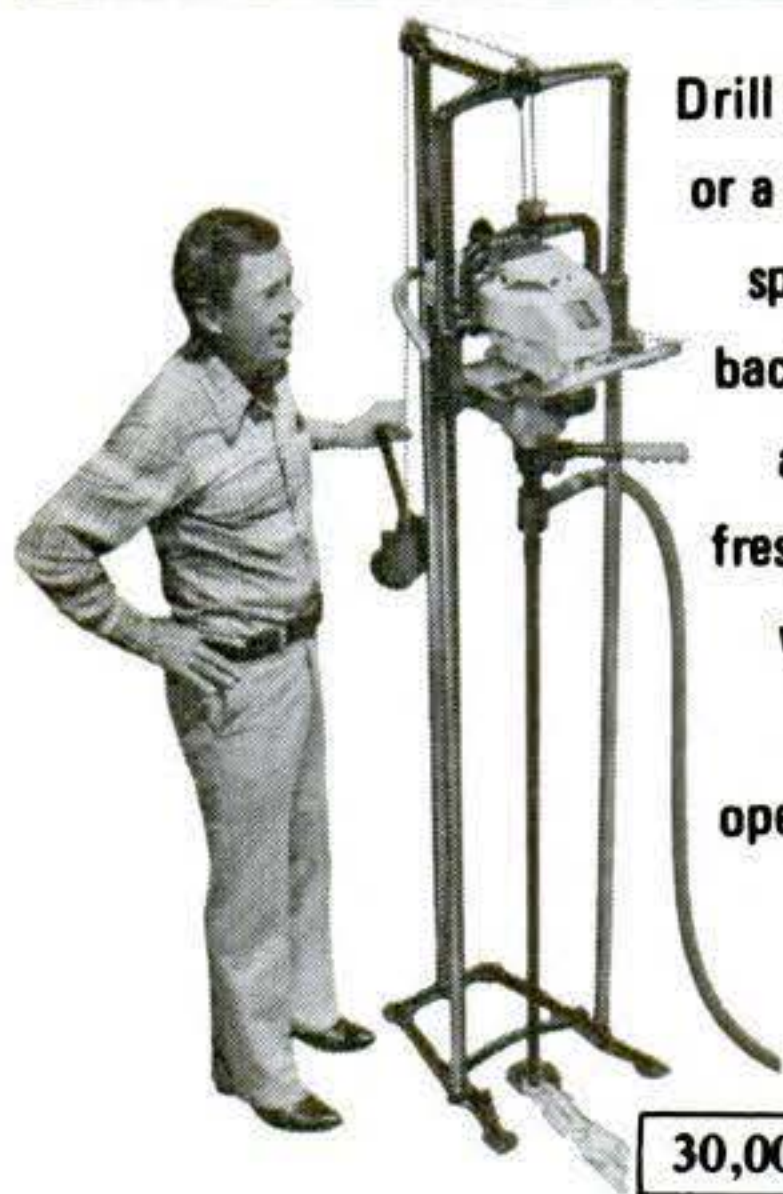
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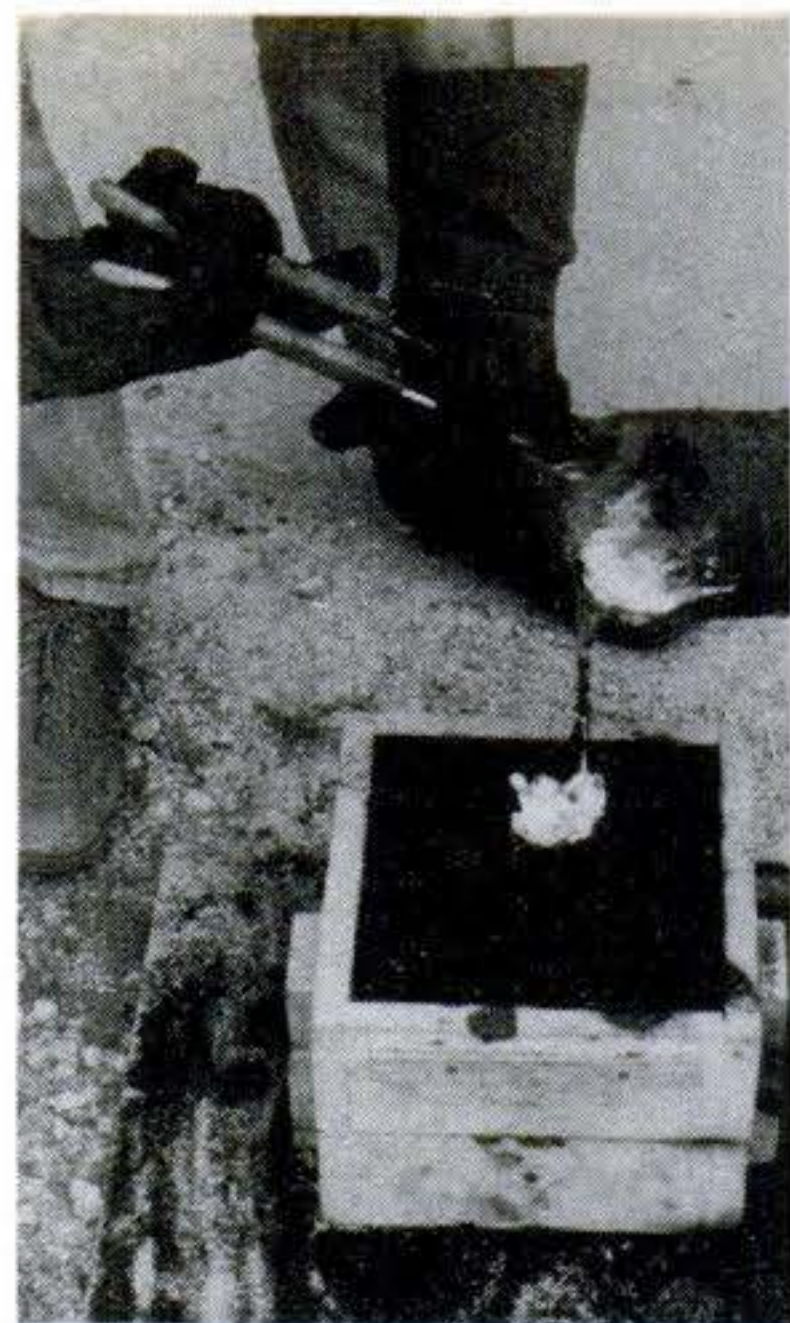
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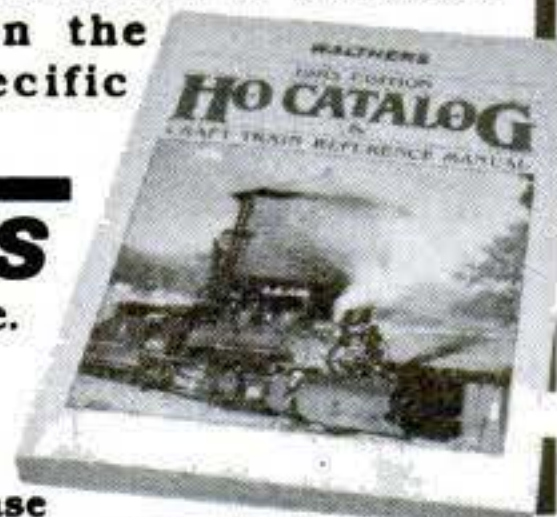
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Is Lower Back Pain Making You An On-Again, Off-Again Cripple?

by Eugene Griffin

Read how one man freed himself from this crippling pain.

It happened aboard a Lufthansa flight to Frankfurt, Germany where I was going for a business meeting. The plane hit an air pocket and suddenly my back "went out."

If you've ever suffered from lower back pain, you know what this can mean. In my case, the stewardess had to lead me off the plane when we landed. "This is the first time this has happened?" she asked. When I told her no, she said:

"Oh, then you should have a Prosana Belt." She then told me she had lower back trouble, too, and without the Prosana Belt, she didn't think she could hold her job. "It practically saved my life!" she went on.

"I'll be sure to get one, I told her. But what I was really thinking was how could a belt that helped her—a woman about 110 pounds—help a slightly overweight guy of six feet like me? Besides, I thought, I've tried practically everything short of an operation. So I went to my hotel room, took a hot bath, several aspirin and laid down for the night hoping for the best.

Couldn't get out of bed

The next morning the pain was worse than I could ever remember. I had to roll out of bed onto my knees and crawl to a doorknob to get to my feet. Again, I took a hot bath and some aspirin, but again, it didn't do much good. If I had been back home, I would have called and canceled the meeting. But here I was in Germany and scheduled for a meeting with five other businessmen I had set up. So there was nothing I could do but go through with it.

Lunch Included, Too!

The pain must have been apparent the moment I walked into the room because the first man I met smiled sympathetically and said, "You look like your back is bothering you." It is, I answered. "Haven't you heard of the Prosana Belt?" he asked. I nodded yes. "And you don't have one?" he persisted. No, I said, continuing around the room, anxious only to get the meeting over with and go back home.

After the meeting, the man who asked me about the Prosana Belt suggested I join him for lunch. Since he was the key man on the deal, I accepted. But instead of driving me to the restaurant, he took me first to a surgical supply store where he bought me a Prosana Belt. I had no other choice but to put it on right there, though all I

could think of after thanking him was to say, Is that it?

"That's it," he replied. "Now let us take a little walk to a nearby restaurant I know you'll enjoy."

The Most Amazing Walk Of My Life

If I had known the "little walk" was going to take almost a half hour, I never would have gone—business deal or no. But that was all part of his plan! Because by the time we reached the restaurant, my pain was gone! I even reached down and touched my shoelaces just to see if I wasn't imagining things. I can't believe it, I said. It's like a miracle. "Yes, I know," he answered, "I said the same thing when I first wore the Prosana Belt. Occasionally," he added, "I still say it, although any troublesome condition or pain that persists should be brought to the attention of your doctor."

Tested & Proved In Hospitals

Over lunch my friend proceeded to tell me about the Prosana Belt. How it was invented by a doctor, tested and proved in hospitals and clinics; even on people so crippled with lower back pain, they had to wear steel braces! How it was, and is, used throughout Europe by tennis champions, Olympic bobsled medalists, soccer players—by all kinds of people who are constantly putting incredible strains and stresses on their backs. In fact, he concluded, its effectiveness has been so proven, its purchase is included under Germany's national health coverage plan.

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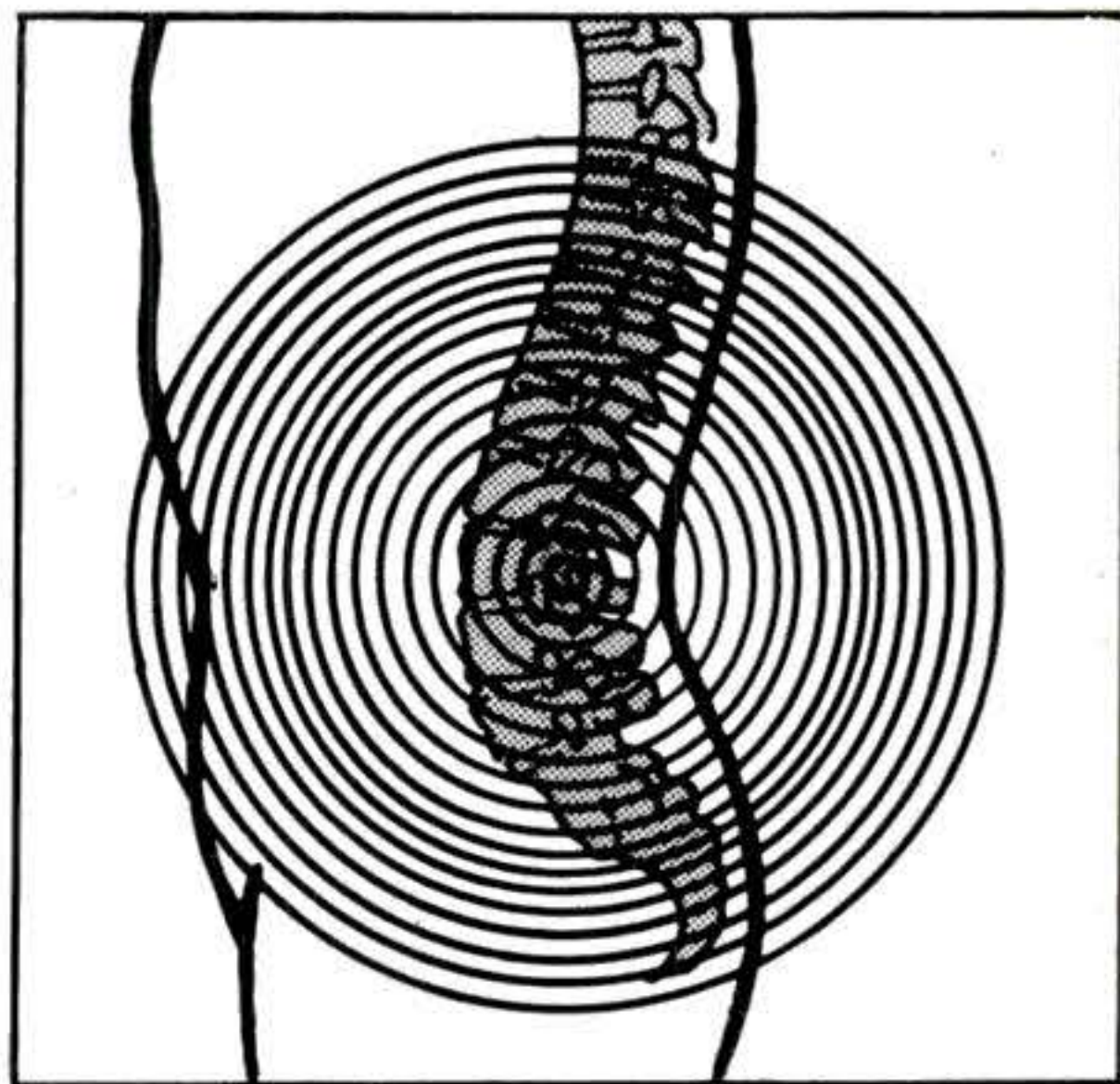
When I returned home, I told all my friends with bad backs about this marvelous belt. But when they tried to buy one, they found no one in the United States had even heard of it! So, I called my friend in Germany (incidentally, I got that order) and told him I'd like to import some Prosana Belts. He told me the cost of one in Germany was \$44.00 in American money. Since I would have shipping costs, taxes, handling and so forth, I decided to see if I could make a special bulk importing deal with the manufacturer. And, I'm happy to add, I was able to. Yes, you can now try the Prosana Belt for only \$29.95—\$14.00 less than what you would pay in Germany. What's more...

You Can Prove Its Effectiveness To Yourself Risk-Free For 30 Days!

If you suffer lower back pain like me, you've probably tried every "cure" there is and so you're probably skeptical. Which is why I'm making this iron-clad, no-risk guarantee: If you're not convinced that the Prosana Belt relieves your lower back pain fast...that it works where other methods and devices have failed...that it lets you bend over, garden, do household chores, even play sports pain-free, I'll return your money in full.

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If You Read Nothing Else Read This Doctor's Report:

"I've turned from my initial skepticism, indeed rejection of the Prosana belt, to an eager proponent of it. I now have checked more than 40 cases from my practice and after studying a file with more than 100 statements, I have no doubts about the effectiveness of the belt."

Dr. Ludwig Hecht

HERE'S WHAT USERS SAY:

"I have been suffering from lower back pain for years. Nothing helped, not even a steel corset. After wearing the belt, I am freed from the pain and it has never come back."

Mr. H. Kilian, Olympic Medalist & 3-Time World Bobsled Champion

"I suffered from severe back pain caused by tennis, and since I did not want to take any medication, I have begun to wear your belt. It is hard to believe how quickly I have got rid of my back pain."

Mr. D. Sturza, Swiss Tennis Champion

"Often I could tolerate the pain only with strong medication. The Prosana Belt has freed me from taking pills."

Mrs. F. Polenz, Housewife

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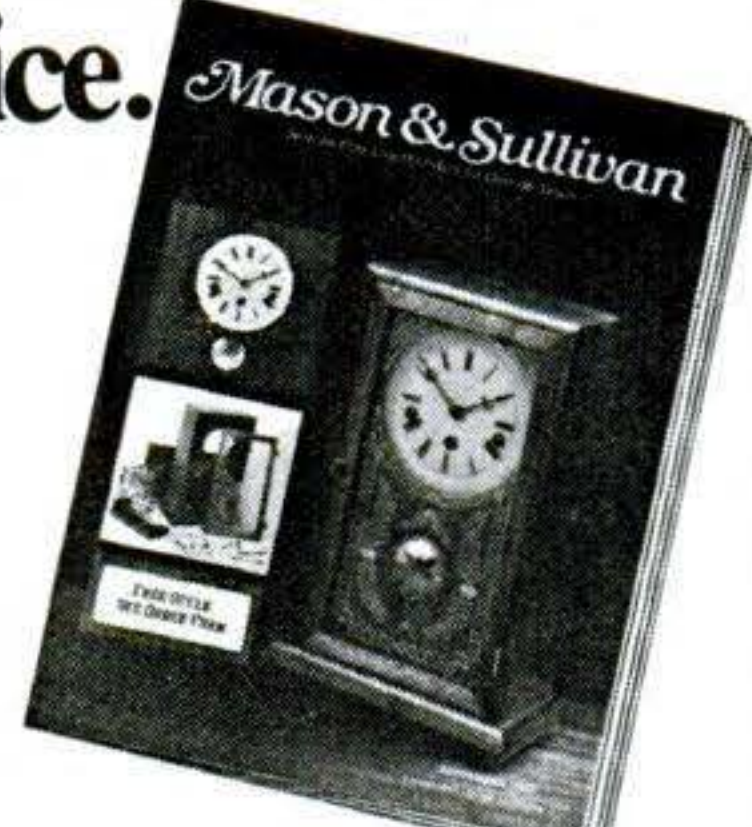
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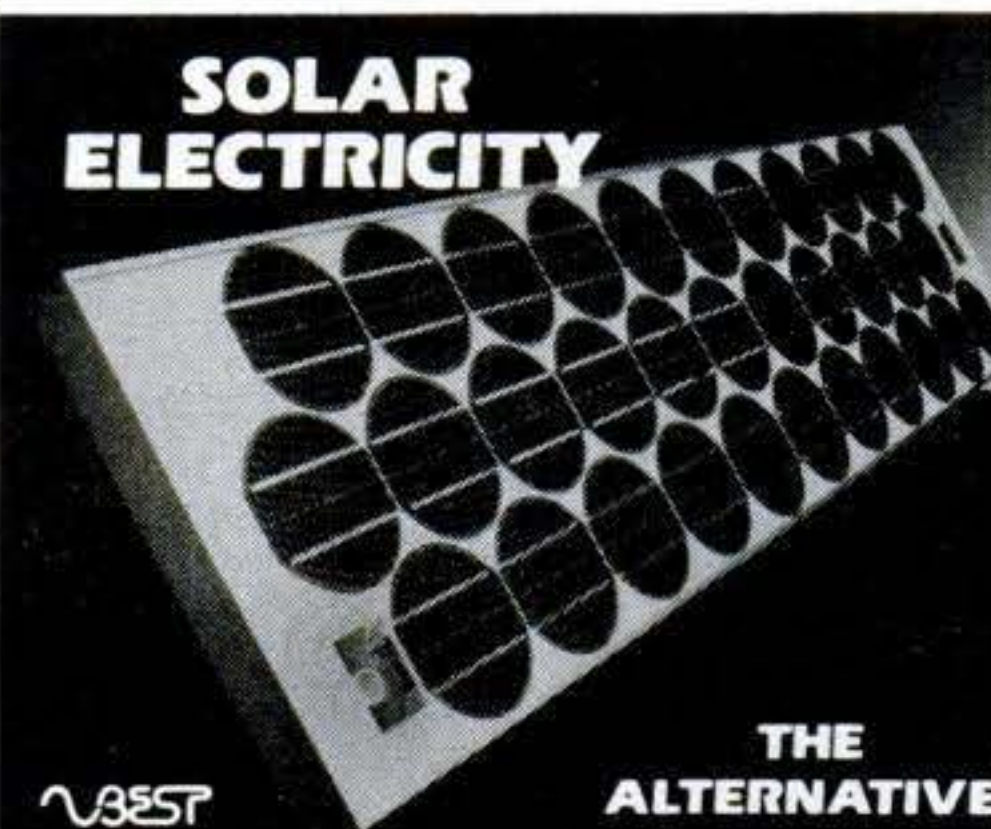
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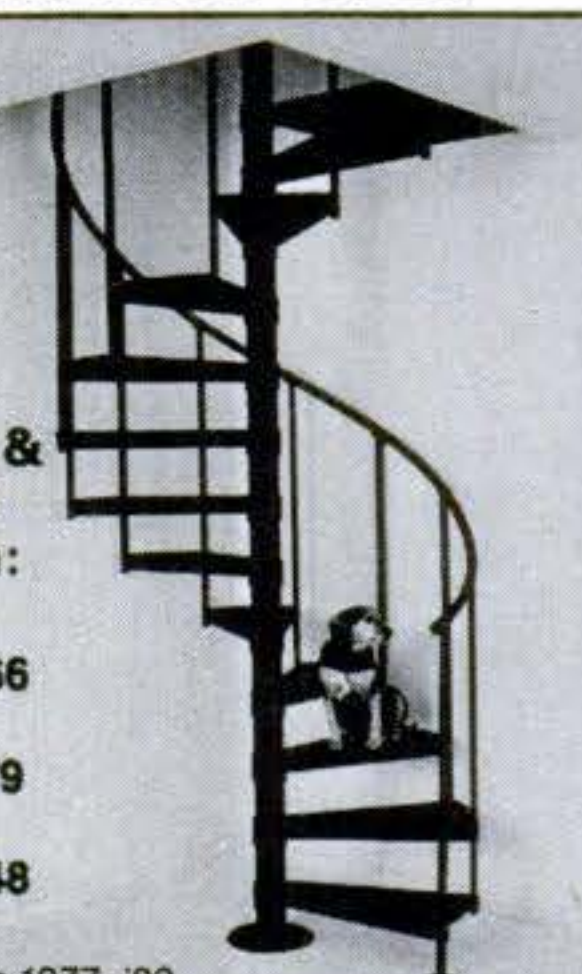
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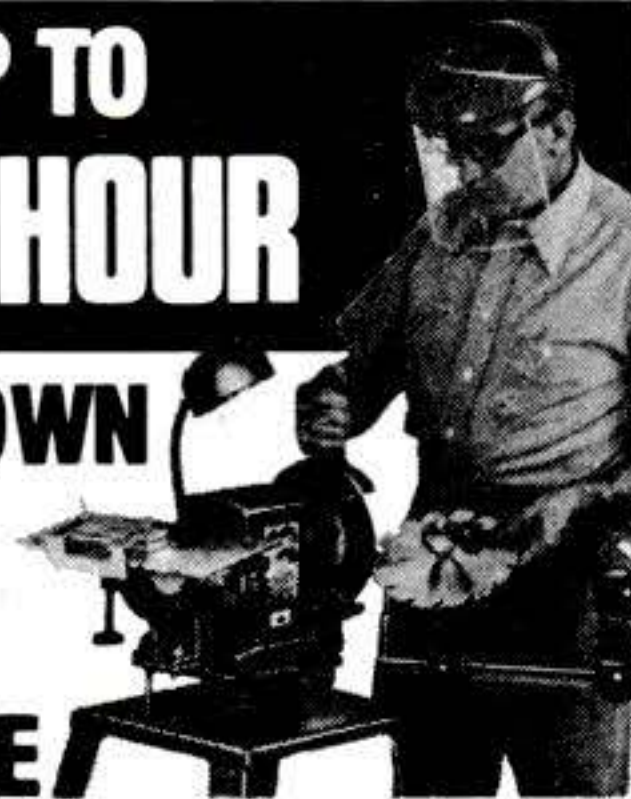
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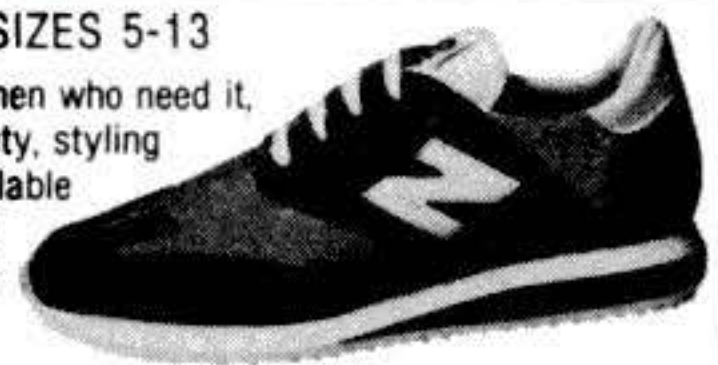
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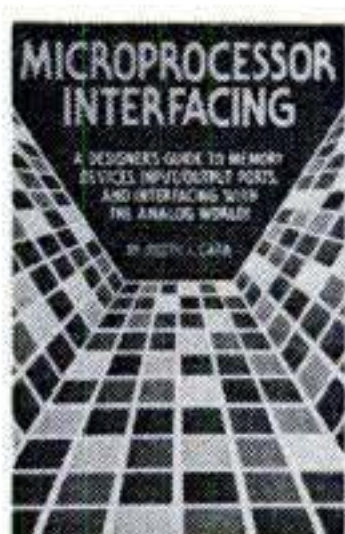
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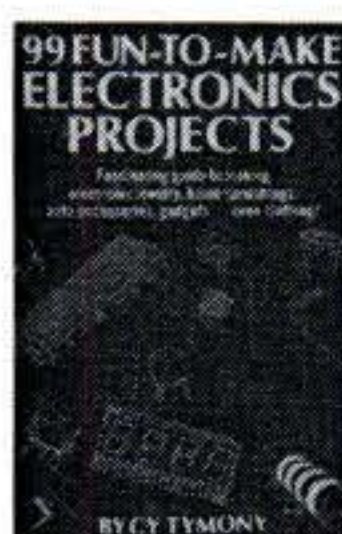
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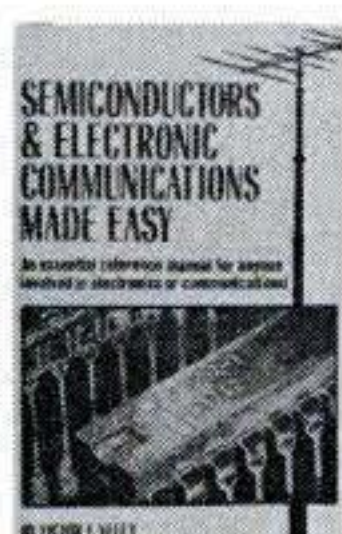
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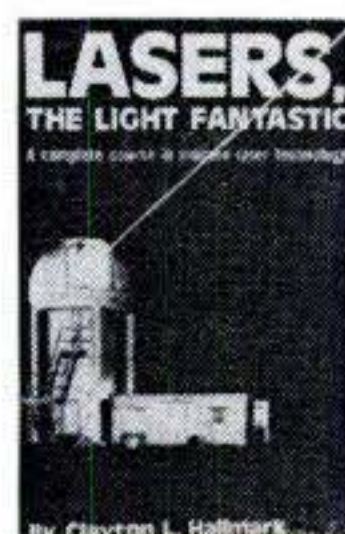
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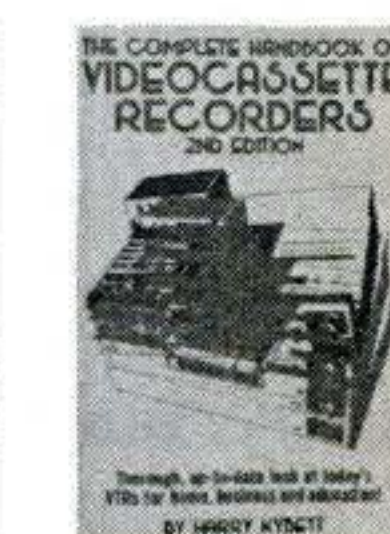
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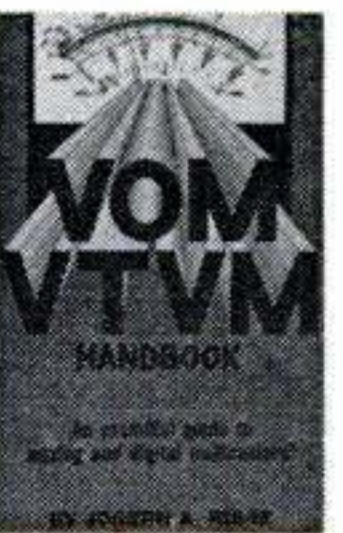
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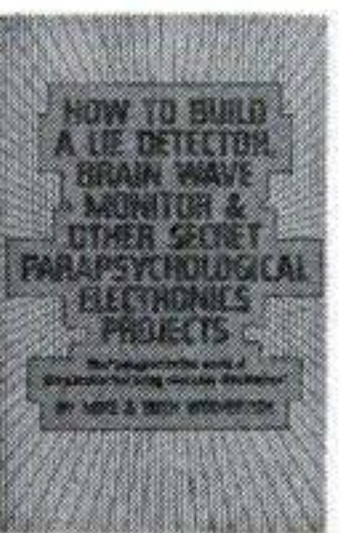
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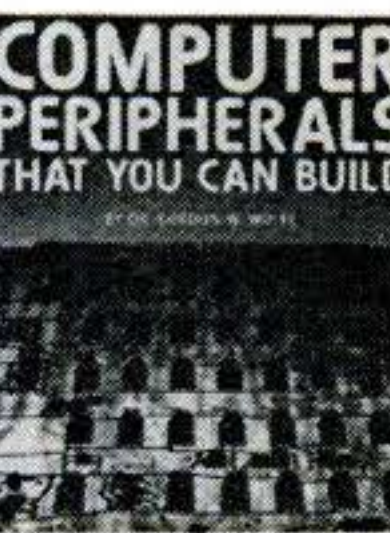
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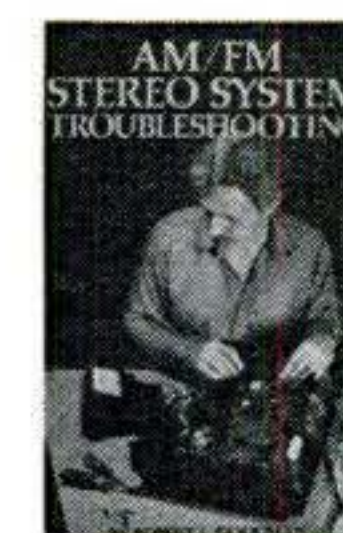
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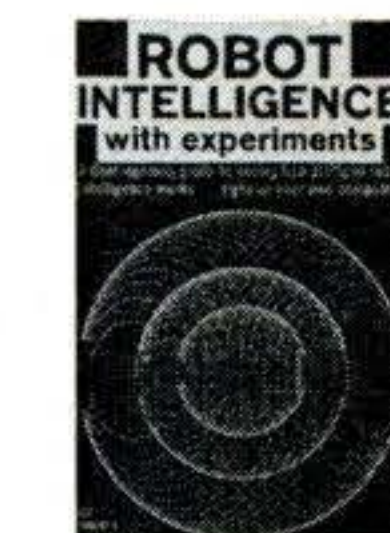
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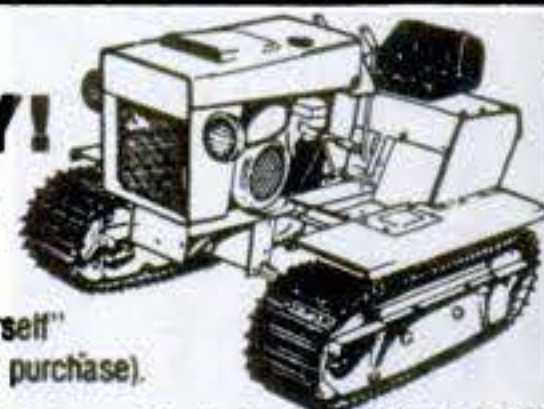


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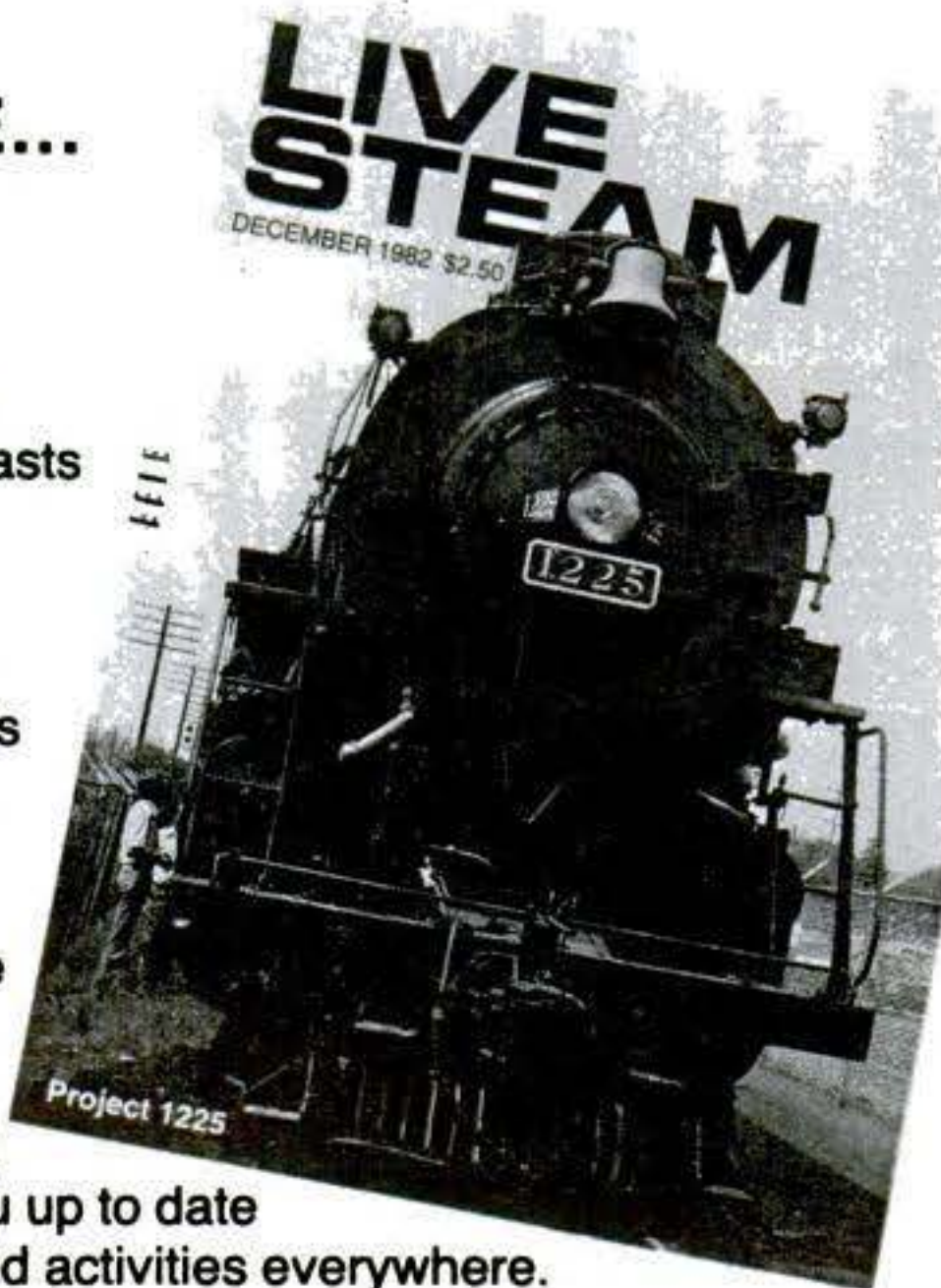
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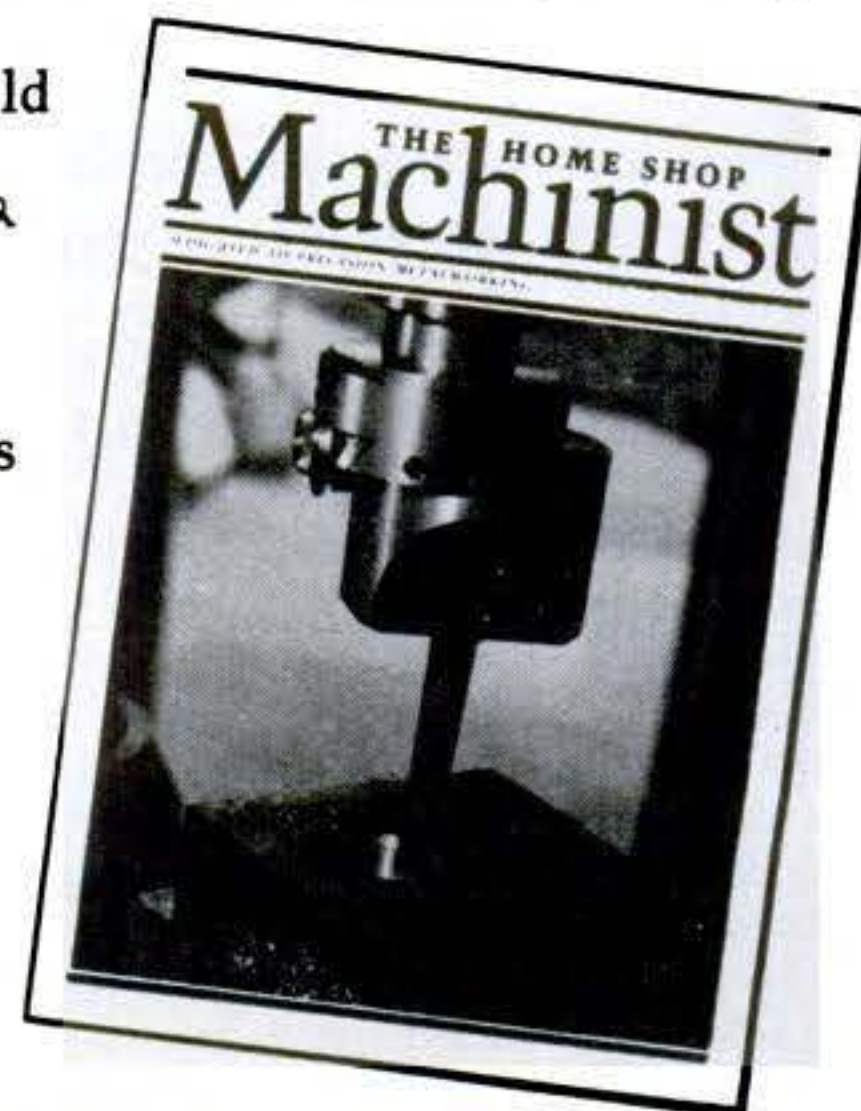


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* ALL MODELS SAFETY TESTED TO UNDERWRITERS LAB. SPEC., BY GEISSER ENGRS.

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55-Gal.
bottom kit
factory pick-up

\$28.95

30 Gal.
bottom kit
factory pick-up

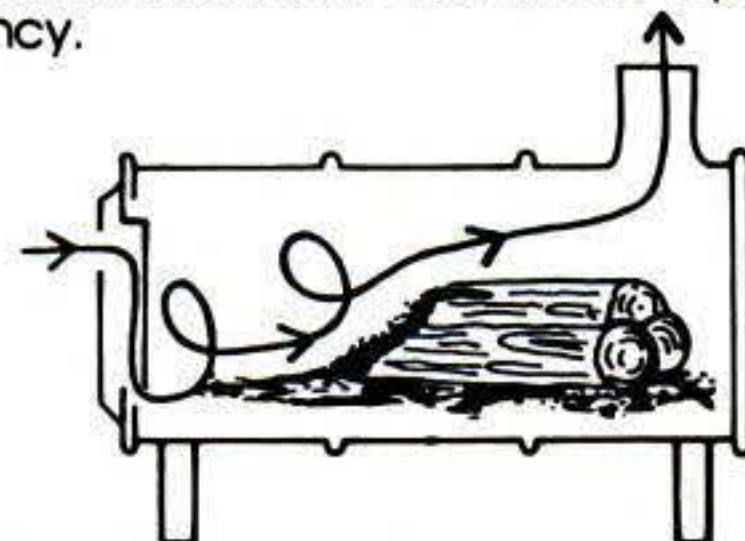
Kit converts 55 gal., or 30 to 15 gal., drum (not supplied) into high capacity stoves.



Burns over 24 hours.

SPECIFICATIONS: Door, door frame, flue collar, draft control, internal draft channel of 13 ga. steel; legs, 1/8 in. steel, hinges, latch, catch of 3/16 in. steel, nuts and bolts. Top Drum: Connector flanges, pipe assembly, 4 nesting brackets, nuts and bolts. 55 Gal. stove has KING SIZE 15 1/2" diagonal door opening. 30 Gal. stove has 9 1/4" round door.

Patented INTERNAL DRAFT CHANNEL-Air entering top draft control is preheated as it is drawn down inside of door and is sucked into bottom of heater with a turbulent action, mixing with the wood gases. This makes the Sotz stove tops in efficiency.



SPARK-PROOF DESIGN Because of our internal draft channel, hot sparks cannot jump out of heater as in others with draft straight open to fire.

GUARANTEE. Try the Sotz Heater Kit at our risk. If (within one year) you don't agree it outperforms any wood heater money can buy, or (within 10 years) if the kit cracks, warps, or burns up, your money will be refunded. Including shipping charges. We have been in business 26 years to back it up. Write for free information.

Sotz Corporation, 13639 Station Rd., Columbia Station, OH 44028

BARREL STOVE'S UGLY

People have told me this when they walk in my door. As far as I'm concerned, they can keep on walking, unless they've got five minutes and want to hear and witness just how beautiful that barrel stove is. Last year '78 (where the barrel stove is now located) there was a \$265 Wood Master Stove. In the beginning the V.M.S. burned 12-14 hours and gave nice heat. Three months from installation of the W.M.S. and some hard burning, the V.M.S. defaulted. Melted metal, air leaks and warpage caused the W.M.S. to lose its lasting and heating qualities. By now 7 to 8 hours burn time was tops and it smoked occasionally inside the house. This year we have your barrel stove. 22-24 hours burn time, even heat, hasn't warped, does not smoke (even after some hard burning). Last year our electric bill was \$40 to \$50 per month. This year \$20-\$25 per month. Why so cheap? Simply by placing an H2O tank . . . to heat domestic water, we've bypassed our electric hot water heater. Savings of approximately \$175 per winter. Prior to installing the barrel stove, I installed a \$600 Frontier Stove in front of my fireplace. This is at the opposite end of the house from my barrel stove. My basement is 30' x 60' x 9 1/2' ceiling. Although the Frontier Stove works good, I don't need it. The barrel stove alone, keeps my basement 72 degrees. Anyone interested in a \$600 Frontier Stove for \$550? (Used for 2 months.) **HAT BARREL STOVE IS BEAUTIFUL!** I've dropped it, kicked it, rolled it, burnt trash in it — she still works beautifully. I can even pick it up and carry it

myself. If I can sell my Frontier Stove, I will have saved \$982 this winter. Almost \$1,000 — NOW, ISN'T THAT BARREL STOVE BEAUTIFUL??

Dick Motter, Jersey Shore, Pa.

DON'T GET BURNT

The bottom drum kit that I bought a few years ago really works good. It heats my garage 24 x 24 in about twenty minutes. Just enough time to go in the house and get a coffee. I believe this is the first time that I ordered anything through the mail that I didn't get burnt.

George Bluda, McKeesport, Pa.

LEAKY, UNCONTROLLABLE

Send me one of your barrel stove kits. I've seen your ads for years in the Mother Earth News, but was under the impression your kit was like one my father has used for years; leaky, uncontrollable, etc. In my work as a chimney sweep, I met Peter King of Gonsvoort, N.Y. He was very impressed with your stove kit, and after cleaning his chimney this past season, I'm impressed too! I know how long his stove holds a fire - because after being unattended for 2 days, it's been too hot to handle and the creosote deposits were consistent with most well managed airtights. Congratulations!

Jeff Payne, Fort Edward, N.Y.

MONSTER DISAPPEARS!

Your Monster Maul is the best log splitter I've seen yet. Although I haven't seen mine for some time because when one friend gets done with it there is another waiting in line for its use. Thank you for

such an honest product at an honest price, rarely seen in this day and age.

Ed L. Lucas, Hemingford, Neb.

WILL BARRELS BURN UP?

Please send your current catalog as I have 2 prospects for some of your heaters. I have been using mine since 1978 and am very well pleased with it. Everyone that I talked to around here said it would not work, that the barrel would burn through in no time at all. Well if that is the case I wonder how they would explain the original paint on the barrel that was on it when I got the barrel. Thanks again for a fine product.

Gerald Fulkroad, Millersburg, Pa.

CUSTOMER FIRST

Last year, I had the occasion to heat my new house with a 30-H inserted in my Preway Energy Miser fireplace. I realized that the Energy Miser was going to burn all of my wood before the heating season ended, and it wasn't heating much of the house, either. I talked my wife into putting the stove in the fireplace to see what it would do. When she found out that it heated all of my 1,786 sq. ft. house, there was no way that she would let me take it out, even if I had wanted to. I also want to take a second to tell you what I think of your company. I have ordered so many Monster Mauls and 30-H kits from you that I have lost count. I am better pleased each time I deal with you. I consider your company one with a good product, at a reasonable price, which still places the customer first.

John R. Somers, Crisfield, Md.

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Tankless Heater Provides Endless Hot Water



The Hughson family of Pennsylvania

The Hughson family just took 7 showers in a row — the 7th was as hot as the first — and they're saving hundreds on their hot water bills too.

Sound, Simple, Money-Saving Idea

Did you know that much of the energy used to heat your basement tank of water is dissipated right through the walls of the tank itself and into your storage or crawl space area?

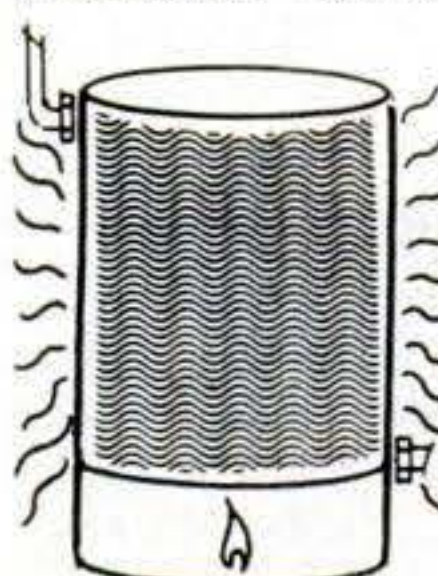
The Perfect Answer—New Thermar™ Tankless Instant Hot Water Heaters

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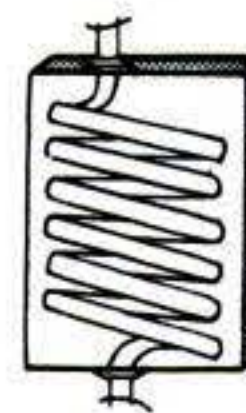
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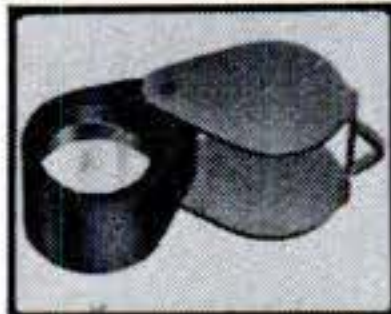
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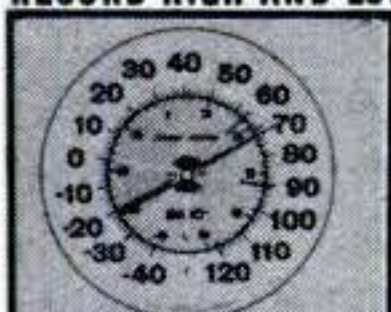
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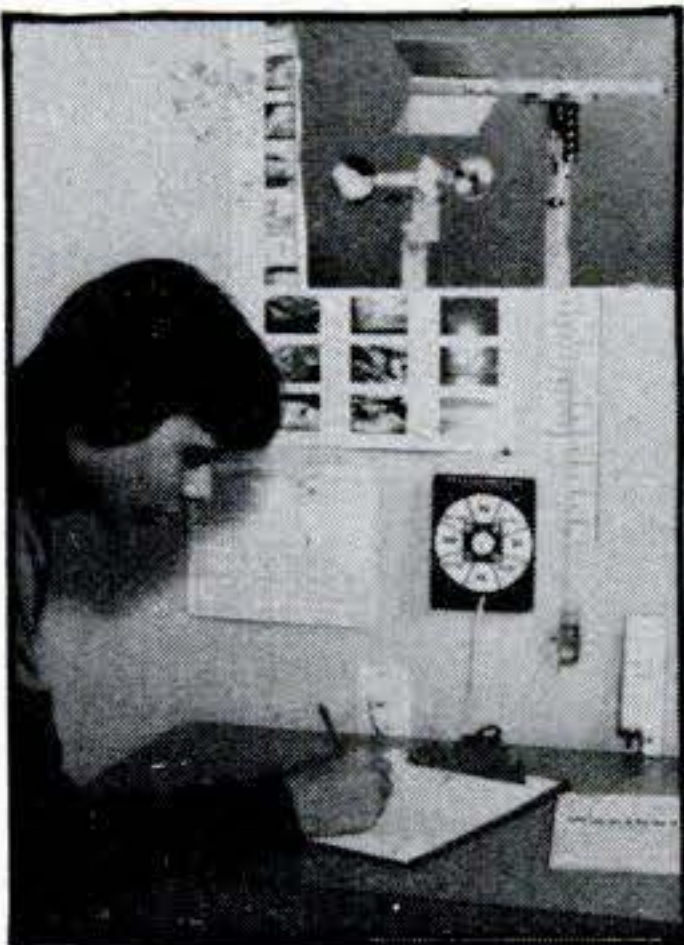


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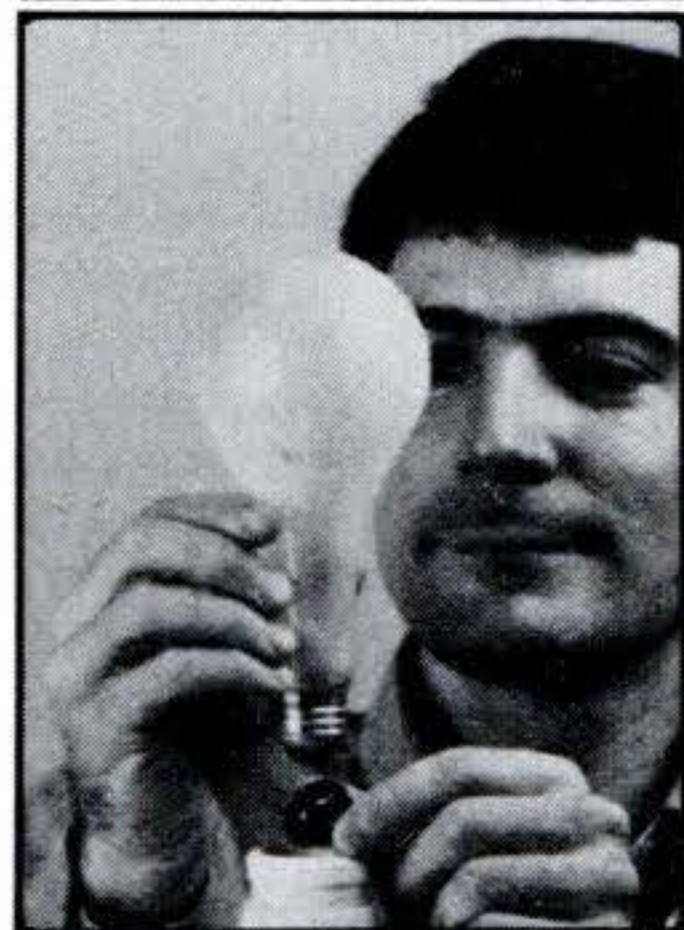
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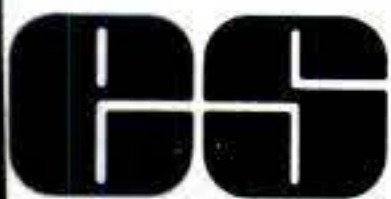
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LOWER PRICED THAN IN 1980

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Construction:	High-carbon steel head, hardened edge. High strength steel handle.
Guarantee:	1-YEAR TRIAL OFFER + 10 years against failure.
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- Forget about lost, stuck, or flying wedges.
- No gasoline, no set-up, no take-down.
- No wooden handles to replace.
- No gimmicks. Just simple physics!

We at Sotz have been making the same quiet offer for years: Try a Monster Maul at our risk! Within one year, if you don't think it's the fastest, least tiring method of splitting firewood, let us know, and we will give you your money back, including shipping . . . Plus, it's guaranteed against failure for 10 years.

OUR 26TH YEAR

Sotz Corporation, 13639 Station Rd., Columbia Station, OH 44028



24" OAK

SPORTSMAN'S CHALLENGE

I have easily split several cords of firewood consisting of white oak, cherry, poplar, and maple, all with amazing speed and with minimal physical exertion. I've even participated in a "Sportsman's Challenge" against a hydraulic splitter, against which my...maul proved much faster. My only regret is I have now sold the maul to the owner of the gas powered hydraulic splitter, who was completely amazed by its performance. During these times of phony advertising and cheap workmanship, I am truly thankful to find a firm who is honest and sincere and provides quality products.

David A. Hojnacki, Monroe, Mi

82 YEARS YOUNG!

If I could not replace it, I'd not sell the maul for \$50.00. I've used nothing in its class and I was born in 1900. I'm enclosing \$24.95, for another so I'll have a "loaner" and one to use myself. My friends, family and neighbors. . . have all been astonished and delighted with it. You don't know how good it is to use your splitter instead of my Kelly double bit axe. With the axe I used (lost) half my working time freeing the blade when it sunk in but the wood didn't split. Your maul usually splits the block with one blow, if not, it bounces free and I swing again.

Herbert C. Root, Vidor, Tex.

LANGLEY'S PLEASURE

Ker Paw!!! means one good swing with my Monster Maul and my block of wood

is cut in two. What a wood splitter it is and the metal handle is no draw back at all. I've always liked to cut and split wood, but my...Chain Saw; my Sotz Lift-N-Saw, and my Sotz Monster Maul has taken the chore out of it, and replaced it with pleasure.

Tom Langley, Canon City, Co

SPLITS OVER 150 CORDS IN ONE SEASON!

Over a year ago, I purchased your Sotz Monster Maul and have never been happier. My husband and I have in just one winter season split over 150 cords of oak and assorted hard woods with your maul. We recently received your latest edition of the Sotz News and I really was impressed with your Lift N Saw...There have been too many occasions where our saw has been jammed or we take our chances and hope we don't hit a rock, but we're never that lucky. Again, thank you for a really fantastic product. I can see why you guarantee your products for so long. They're really worth it.

Dawna Beckmann, Lenox, Mass.

OIL BILL CUT \$300 TO \$80

I am completing one heating season using your drum heater. I have a six room house and it did a wonderful job heating. I cut my oil bill from \$300.00 a year to \$80.00 a year. I have not found a stove to compare it with. Keep up the good work.

Raymond Hutchins, Andover, Me.

BAN THE WEDGE

Football fans know that the "flying wedge" has been banned for years, and

the Monster Maul is doing its part to rid woodsplitters of the problem. My order for the Lift-N-Saw tree lifter is enclosed, to assure that my "Back" stays healthy for the entire season.

W.M. Findlay, Chandler, Tex.

A HEARTY "ALL RIGHT"

I bought a "Monster Maul". Best move I ever made. Your product does what you say it will. After my wood was split, my friends had to give it a try. To a man, each who tried it bought one. The end result was: R. Jones bought two; R. Franklin, one; D. Witt, one; E. Crosson, one. Your maul is your best advertisement, once you use it, you have to have one of your own. Could have sold mine over and over but—use, yes; buy, "NOT ON YOUR LIFE"! Thank you for a tough product built in the Old American tradition. It works and it doesn't break. So, from all the wood splitters at the Thos. Somerville Co., Annapolis Branch, a hearty "All Right."

L. Mould, Annapolis, Md.

STEEL VERSUS ASH!

I compliment you on manufacturing a splitting maul that exceeded my strongest hopes. It works like nothing else I've ever used. I used it on oak logs 20" long and ranging up to 24" in diameter, and it split them cleanly with one swing. It out-performed wedges so much that I no longer even bring wedges along when splitting wood. You have an excellent product. Your idea of incorporating a steel handle, instead of the usual ash, makes it a tool that I'm sure will last for my lifetime and my children's.

George L. Voss, Portland, Ore.

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• ITEM #9-1169 - 13.2-GPM at 3500-RPM. IN port 3/4" NPT, OUT port 1/2" NPT, shaft diam. 1/2". Use with 5-HP engine. 6-1/2" x 4-1/4" x 4". (12 lbs.)

F.O.B. Lincoln

\$147.50

• ITEM #9-1170 - 15.2-GPM at 3500-RPM. Use with 8-HP engine. Other specs. same as above. (12 lbs.)

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• ITEM #9-1171 - 21.6-GPM at 3500-RPM. IN port 1-5/8" UN SAE O-ring, OUT port 1-5/16" UN SAE O-ring. Shaft 5/8" diam. Use with 10-HP engine. 10" x 6" x 5". (33 lbs.)

ITEM 9-1171



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- 2 lbs.

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- fiberglass handle
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- 1 1/2 lbs.

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- 5" edge
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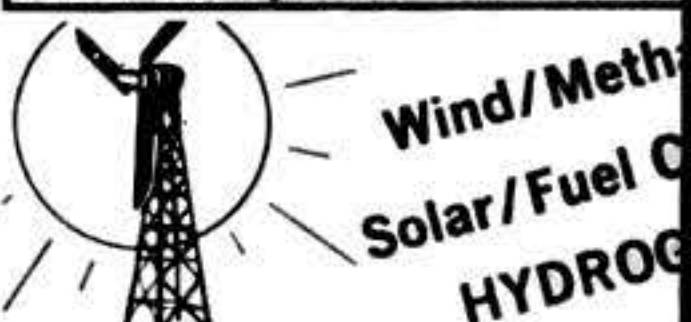
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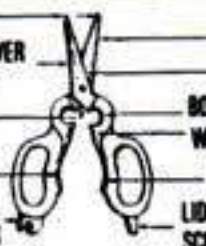
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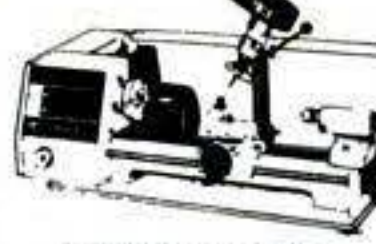
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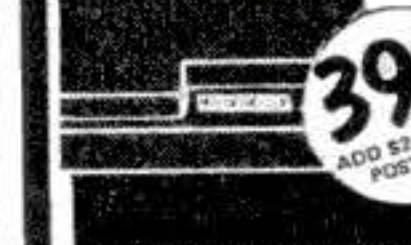
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101 Silent Insect Killer Aladdin Bug Battler kills 300 insect varieties silently. Insects are lured into a water trap and drown—with no sizzle or popping sound. A brochure describes the concept. Free

102 Window Replacement Take advantage of the energy savings possible with new windows. A 16-page, full-color booklet illustrates different styles of replacement windows available from Andersen Corp. Free

103 Government Surplus Hard-to-get items for hobbyist, mechanic, or sportsman are described in the 1982 Airborne Surplus Catalog. Bargains include savings of up to 90 percent on government surplus. \$1 (refundable on first order of \$10 or more)

104 Brush Care This how-to folder explains proper cleaning and care of your paintbrushes. It also lists substances harmful to brushes and the advantages of using B&J Brush Soap. Free

105 Gas-Pressure Shock Absorbers Full-color brochure describes the technology and applications for all Bilstein gas-pressure shock absorbers for foreign and domestic cars through 1982. \$2.50

106 Tire Information Brochure from Bridgestone Tire Company of America, Inc., details its current line of tires for domestic and imported cars. New advanced-technology Super-Filler steel-belted radials are highlighted. Free

107 Ironwood Fireplace-Stove Lower your thermostat and gain up to 50,000 Btu per hour—right from your fireplace. It's as heat-efficient as many smaller home furnaces. Complete booklet from CWC Textron. \$1

108 Guide to Kerosene Heaters Booklet from PFS Corp. provides information about the economics and advantages of kerosene heaters: what type to buy, the correct fuel to use, safety tips, and proper care and maintenance. \$3.95

109 Window-Replacement Guide Don't rip out and rebuild walls. See how easy it is to replace old windows with energy-efficient Caradco wood windows in this 12-page Fast Fit guide. It gives step-by-step instructions. \$1.50

110 Telephone Efficiency This 12-page, full-color brochure from Cobra on telephone equipment includes memory phone, cordless phones, wired phones, answering systems, auto dialers, and accessories. Free

111 Rugged Pickup Trucks This full-color brochure from Toyota features its tough, dependable trucks—everything from sporty SR5's to rugged 4x4's. Free

112 Save Fuel Keep oil temperature down and extend the life of your car's engine and transmission—take a load off your engine. Brochures available from Hayden Inc. Free

113 Recreational Vehicles Literature from Jayco, Inc., shows its full selection of recreational vehicles—including complete floor plans, specifications, and construction features for tent campers, fifth wheels, pickup-truck campers, mini motor homes, van conversions, park trailers, and three lines of travel trailers. Free

114 Fun-Filled Catalog New 1983 catalog from Johnson Smith Co. features 1,600 hard-to-get novelties, jokes, tricks, and hobby, sports, science, and electronics items. Much more. 10¢

115 History of Old Bushmills A three-page, four-color brochure from Jos. Garneau Co. details the history of Old Bushmills Irish Whiskey. It also includes recipes for using Old Bushmills in food and drink. Free

116 Keep Your Diesel Happy This pocket brochure from Kendall Refining Co. tells how a diesel engine is different from a gasoline engine. It also describes proper maintenance for diesels. Free

117 All-Purpose Shelters This catalog from Kover Klamps Div. describes how to build greenhouses, car or boat ports, shelters for pool, patio, tools, lawn mower, and more by using Kover Klamps and metallic tubing. Free

118 Lower-Back Pain Are you suffering needlessly? A new report from Lumbar Institute Research Div. shows how thousands have obtained relief. Free

119 Washerless Faucets Easy, do-it-yourself installation of an exciting array of single- and two-handle washerless faucets is described in the full-color brochure from Peerless. Free

120 Marine Paints Literature from Pettit shows its complete line of paints and over 300 different products. It also explains how, when, and where to use them. Color card and finishing instructions are included. \$1

121 Software for Home Computers This descriptive catalog from Program Design, Inc., describes more than 40 educational and game titles for Atari and Apple computers. Fun and challenging programs for all ages. Free

122 Energy-Saving Meters This booklet from Portage Exchange describes technically designed products to help increase efficiency and decrease fuel use for wood burning, solar, and furnaces. Free

123 All About Greenhouses An exciting new catalog from Lord & Burnham details information on greenhouses for living, growing, and energy saving. Also includes booklet, "Greenhouse Living," with a special section on solar energy. \$2

124 Home Improvement A colorful listing with nearly 200 pages of quality building materials and home-improvement items is available from Scotty's. \$2

125 Home-Security System Easy-to-follow guide from Security Center details home burglar alarms and security equipment. Includes components and system kits. Do it yourself and save. \$2

126 Heat Machine Literature describes a unit that can be installed in one hour to convert your fireplace into an efficient home-heating system. From Unique Function Products. Free

127 Tools, Tools, and More Tools! All 196 pages of this U.S. General Supply Corp. catalog are filled with top-name tools and supplies. It includes over 6,000 items essential for car care and maintenance, interior and exterior home improvement, wood- and metalworking, and plumbing and electrical projects. Discounted prices, too. \$1 (refundable on first order)

128 Tools and Solderless Connectors This 16-page catalog by Vaco Products Co. contains details on the company's complete line of screwdrivers, nut drivers, pliers, electrical connectors, and much more. 25¢

129 Organ and Piano Kits Colorful booklet from Wersi Electronics shows how to save thousands of dollars by building it yourself. It's enjoyable, easy, and profitable with these simple, illustrated instructions. Instruments offer highest quality, unmatched sound. Free

130 Motor Homes New full-line brochure features nine Xplorer models from Xplorer Motor Home Division. Choose the one that's best for you. Free

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